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Announcement of the Change of Name of This Publishing Company

The name of Engineering and Contracting Publishing Co. has been changed to Gillette Publishing Co. No change of ownership or of publishing policy is involved in the change of name.

This company publishes four monthly magazines, three annual consolidated catalogs, and a group of technical books.

Three of the magazines, Engineering and Contracting, Roads and Streets, and Water Works, are well known to most of our readers. A fourth magazine, Municipal News, has just been added to the group.

Municipal News is the new name of the oldest municipal magazine in America, namely Municipal and County Engineering.

These four magazines will have a combined circulation of not fewer than 75,000 copies monthly, during 1928, distributed thus:

Engineering and Contracting	27,000
Roads and Streets	27,000
Water Works	16,000
Municipal News	5,000
Total	75,000

We take this occasion to invite authors to submit manuscripts or outlines of projected technical books that relate to the fields covered by our four magazines.

We shall be glad to send a sample copy of any of our magazines upon request.

GILLETTE PUBLISHING CO.

The Mistaken Opposition to Highway Bond Issues

Under the title of "The Road Bond Folly," the Grand Rapids Press some time ago printed an editorial that is full of misunderstanding of the economics of bonding for road construction purposes. Yet it is the sort of editorial that sounds plausible and is therefore reprinted by other papers. We shall quote it first in full, and then comment briefly on its errors.

Gov. Small of Illinois, forcing through his legislature a bond issue bill of $174,000,000 for good roads, offers to the entire nation an example of the wrong way to finance and build highways. It comes at a time when the country needs a lesson.

Before the roads authorized in this bill are paid for, which means in the thirty years of the issue, they will have been worn out and replaced several times. No profit whatever lies in passing on the burden to the future in this way, multiplying the total amount spent by an interest charge which will bring the whole cost to more than half a billion. Highways are a type of public construction which should be paid for out of current receipts as the work goes on. Maintenance and replacement is more or less constant. Anyone can appreciate the difference between a bond issue for quick depreciating roads which will be a persistent expense anyway, and a bond issue for a local school house which will last for thirty years. If a town could be sure that its expansion would require a new schoolhouse every year it would be folly to bond and pay interest.

Politics and patronage of course had a tremendous part in the Illinois program; votes were sold for unnecessary "neighborhood roads" throughout the state. Michigan has a sound and sane highway plan. Though this state also passed a tremendous road bond issue during the big figure period after the war, the people as a whole have come to their senses and are all for paying as they go, by such means as the gasoline tax.

A legitimate complaint against the Groesbeck administration is that the governor's political manipulations have obliged us to play the boob trick of further bond selling this summer, and imitating, though we know better, the plan of Gov. Small.

It is evident that the editor who penned this criticism of bond issues for road construction knows very little about the history of road building in America. It was not until New Jersey, Massachusetts, Connecticut and New York, in the early 90's, adopted "state aid in road building" that the first marked advance in road improvement began. State aid spread half the tax burden over the entire state, and bonding spread it over a long period of years, thus making it feasible to build hard roads at a fairly rapid rate. Prior to that America had been noted for its "mud canals" and "dust reservoirs," as its roads were designated. Then state after state followed the precedent set by the four states above named, until not a single state remains that does not share in the cost of road improvement, and nearly all of them have issued bonds for the purpose.

"State aid" and bonding have been the means by which great progress in road improvement has been made. It is a mistake, therefore, to condemn either "state aid" or bonding.

Turning to the broad question of bonding for construction purposes, let us consider its economic features. The people who buy bonds furnish all or part of the money with which to build. Railroads, public utility and industrial companies raise about half their capital through the issuance of bonds; and it is conceded that bonding is an economic procedure for them. Tell us, then, wherein what is wise for private corporations is folly for public corporations? Whether the money for construction is raised by bonds or by taxes, it is secured from that part of the public that possesses capital. But the possessor of capital is always loath to part with much of it unless he sees a quid pro quo, and he seldom sees any quid for his quo when directly taxed. On the other hand, if he is paid interest he gladly lends large sums of money that he would fight against having taken from him as a tax.

Of course the interest on public bonds must be raised by taxation, but annual interest at 5 per cent is readily secured

by taxation, whereas a bitter battle would be waged against paying the full 100 per cent of the construction cost at one stroke. It is 20 times easier to get the annual interest plus a small sinking fund than it is to get the entire principal at once by taxation.

The only important questions that remain are two: (1) Are the proposed road improvements desirable? (2) How shall the interest on the bonds be raised?

Road improvement, rapid though it seems to be, lags far behind the requirements. The annual expenditure for motor vehicles is several fold the annual expenditure for highways. Our road improvement program is really in its infancy, even though most of the roads themselves are old.

The gasoline tax furnishes one excellent method of financing road improvement. Doubtless real estate taxation should also be used to raise the needed funds.

The Grand Rapids Press states that the roads will have been worn out and replaced several times during the 30-year life of road bonds. This also is a mistake. The culverts, bridges, roadbed and road foundation usually have a life far greater than 30 years. Road surfacing may average less than 30 years, although we believe that for most country roads the life of a well built surface on a proper foundation will equal or exceed 30 years. But whether the life of the road surface is more or less than 30 years has nothing whatever to do with the question of bonding. The crossties in a railway track average about 10 years in life; the rails, 20 years; the rolling stock, 25 years; and even the bridges and buildings, for the most, do not outlive the initial bond issues. The equipment of modern industrial plants has a life of about 10 years. The average life of the entire telephone plant and equipment in America is less than 20 years; and about the same is true of the life of electric light and power plants. Yet bond issues of 30 to 50 years are common for all such properties. All that is needed (and utility bond holders insist upon this point) is that replacements and repairs be paid out of current income and not by new issues of bonds. The very same practice can be, and usually is, adopted by our states, counties and cities in maintaining our highways.

The editor speaks from an experience of 35 years in the highway field and more than 20 years in the public utility field. And in both fields he has gathered a great deal of data, so that his conclusions are founded on many facts and no fancies.

The Prospect of a Five-Day Week

"Man's work is from sun to sun,
But woman's work is never done,"

seems an ancient saw, yet it may be not much more than a century old, for within the last century the common work day was from sunrise to sundown. As late as 1840 the average work day was 11 hours long, and in 1890 it was 10 hours long, according to the statistician, Falkner, in the celebrated Aldrich committee report to the United States Senate. To men of 40 years or older it is needless to say that there were six full days in the working week for nearly all workers prior to 1890.

Now that we are entering the era of the 5-day week, and are hearing many condemnations of it, let us look backward a little at the progressive decrease in working hours. We may then be less sure that the 40-hour week is many years ahead of its schedule, and we may also see that it will become universal only by degrees and only as the average output per worker increases.

More than five years ago, in Engineering and Contracting, Aug. 31, 1921, the editor summarized an extensive investigation that he had made into the matter of wages and commodity prices. He showed there that the average wages in America had approximately paralleled per capita money, and that per capita money had approximately paralleled per capita productivity. Hence, average wages had been proportional to the productive efficiency of the workers. It also was shown that the wage level was five times as high in 1914 as in 1814, although commodity price levels were about the same in those two periods.

Since the average working week was probably not much less than 72 hours long in 1814, and not much more than 48 hours in 1914, we see a decrease of about one-third in the working hours accompanying a 400 per cent increase in productivity and in wages, both money wages and "real" wages.

The 44-hour week is quite general now, and it has taken only 12 years to attain it since the 48-hour week became general. In light of such facts it seems reasonable to anticipate that the 40-hour week will be prevalent within 10 years. It has arrived in one large factory that is noted for its high productivity per worker, and will doubtless be adopted here and there by other factories whose employees show high efficiency. But as the 48-hour week was slow in spreading, and as the 44-hour week was equally slow in being generally adopted, so will the 40-hour week make slow progress.

The 40-hour week seems likely to be adopted in the building industry before it finds general acceptance by any other industry, because the erection of buildings is a local business, and local businesses more readily respond to such an innovation than do those that compete nationally. On the other hand, the building workers' unions may retard the adoption of the 40-hour week by their refusal to do 44 hours work in 40 hours, although that increase of output could easily be accomplished.

There are few trades that can show less justification for being granted a five-day week than the building trades, first, because builders do not average 200 days of actual work annually; second, because building artisans, taken as a class, do not attempt to give a full day's effort for a full day's pay. Without realizing it, they are among the beneficiaries of the increased productivity of other classes of workers. Carpenters, brick layers, masons, painters and plumbers still do their work, for the most part, with primitive tools. Since greatly increased productivity is mainly due to machinery, it follows that building artisans have assisted little, if at all, in enabling American workmen to secure the highest "real wages" ever secured. Indeed, it is the consensus of opinion among building contractors that building artisans do much less work per day than they did before the world war, and that even then their union restrictions had made them far less efficient than were their fathers. Had it been the policy of all American workers to restrict output and to oppose the introduction of machinery and piece-rate payments, there would be no such wages for the building artisans as they now enjoy and no five-day week in prospect for them or for any other class of workers.

Let it never be forgotten that the 40-hour week for workers is the direct outcome of the nearly 80-hour week of our Edisons and the engineers and business men who have put their inventions to use.

The Highway Traffic Problem

A Paper Presented at the 13th Annual Road School at Purdue University

By W. A. VAN DUZER

Deputy Engineering Executive, Pennsylvania Department of Highways

Traffic is the human equation and the first cause in the highway problem. Logically, it is fundamental to the highway official, engineer and student. Increased traffic creates additional demands upon the highways. Traffic as a factor enters every principal division of highway activity, administration, finance, location, design, construction and maintenance.

Defining the Traffic Problem.—The traffic problem more often is the future development of transportation than the care for present conditions.

Before the introduction of the automobile, transportation by road was comparatively light. Graded roads were considered adequate to carry the traffic in most places. Gravel or water-bound macadam sufficed to carry the heaviest loads, and except in metropolitan areas there was no crowding of traffic.

Development of the automotive industry, great increase in efficiency of performance of motor vehicles, steady reduction in first costs and in costs of operation, considerable road improvement, increasing population and prosperity have released a flood of highway traffic beyond previous comprehension and we must expect future years to bring increased traffic demands. In certain locations traffic is now overtaxing our improved road facilities, while in other places our roads have not been given any surface improvement. Expediency in most cases demands that the work of completing the system be given priority over the work of reinforcing overloaded parts of the system. The expectation of future large increase in volume of traffic makes the problem serious.

The Traffic Problem in Itself.—The development of motor traffic is largely measured by motor vehicle registration.

In 1895 there were four motor vehicles in the United States; in 1900, there were eight thousand; in 1905, seventy-eight thousand; in 1910, a little under half a million; in 1915, a little under two and one-half million; in 1920, more than nine million; in 1925, nearly twenty million; and in 1926, twenty-two million, three hundred and thirty thousand.

Relation of Motor Vehicle Registrations to Population.—In 1925 there was one motor vehicle to each 6.5 persons of population. In California the ratio of population to registration was lowest (3.20). Iowa was second with a ratio of 4.08; Indiana eleventh with 4.95; Ohio seventeenth with 5.36; Illinois twenty-fourth with 6.32; New York thirty-eighth with 8.25; and Alabama forty-ninth (last) with 14.39.

Pennsylvania is the twenty-ninth state in order with 6.87 persons per motor vehicle as compared with the United States average of 6.5. In Pennsylvania the percentage of rural population is 35.7, while the corresponding figure for the entire United States is *48.6.

What may be the minimum figures of ratio that will be reached in the various states we do not know, but we are certain that the so-called "saturation point" has not been generally reached as yet.

Road systems are not yet complete and their continued development and ultimate completion will undoubtedly encourage increased registrations.

Motor vehicle prices have been decreasing, while almost all other prices have been increasing. The National Automobile Chamber of Commerce in its "Facts and Figures of 1926" shows that from 1914 to 1925 the automobile dollar increased from 1.00 to 1.16, while the cost of living dollar went from 1.00 to 0.59. It is not unreasonable to expect that the future will see continued reduction in prices, and that continued prosperity will sustain increasing motor vehicles registration in ratio to population.

There is a tendency for lighter cars. This has been developed to a high point of efficiency in continental Europe. We may expect similar development in this country.

Relation of Traffic to Registrations.—It is generally assumed that traffic increases with registrations. In other words the theory is that the annual mileage of travel per vehicle remains about the same from year to year so that as the number of motor vehicles in use increases the total of motor vehicle traffic also increases.

As a matter of fact, the combined influence of increased efficiency of automotive equipment, decreased operation costs and increased road facilities (notably uninterrupted use of the roads throughout the winter) must be expected to continuously increase the ratio of traffic to registration from year to year.

Observations in Maine ("Public Roads," May, 1925, page 55) show that the average daily traffic in per cent of total registration increased from 23.6 to 26.0 between 1916 and 1924, and the records of Maryland, Massachusetts and Wisconsin indicate some expansion of annual travel mileage per vehicle between 1919 and 1924 (United States Bureau of Public Roads, and Pennsylvania Department of Highways cooperative survey of transportation.)

The use of the highways by common carriers is a very recent innovation, but the indications are that many of our highways will in the near future carry scheduled passenger and freight conveyances operating under control of the State Public Utilities and Interstate Commerce Commissions.

Within the economics life of the flexible types of road surfaces that we are now building in Pennsylvania, we expect traffic to double in volume.

It is to be expected that United States Census curves produced will provide closely approximate estimates of population for the future years in which we are interested and that the population curve can be applied in attempting the solution of the traffic problem.

The Traffic Problem in Practical Application to Highways Traffic and Administration.—The traffic to be carried determines the layout of the highway system and necessitates or justifies the expenditures of public funds for construction and maintenance, whether the road system under construction is a township unit, a county unit, or a state unit.

Whether the study of the traffic is made through a systematic and comprehensive traffic census and transport survey, or whether the information is that which a local official has gained by his personal familiarity with the road and its environments, it is a general fact that road systems and road improvements are planned and administered for the traffic that they carry, or are expected to carry.

Operation revenues of state highway organizations are almost universally derived from motor vehicle license and gas tax. Hence increasing registrations and traffic provides greater revenue simultaneous with necessity for greater expenditures for road maintenance and the demand for more extensive road improvements.

It is only natural that when question arises as to expenditures for road improvements, the final decision should be based largely on a study of traffic conditions both as to apportionment of funds and manner of expenditure.

There is always the economic law to be considered, that the carrying charges on the road, interest and depreciation, and the maintenance costs, together with the cost of operating for the road users, must be within the

*—1920 U. S. Census.

value of the use of a road to make construction and maintenance a good investment.

Laying Out the System.—The first influence of traffic is in the selection of the road system. It is a general condition that in any given locality a certain percentage of the roads may be designated as of principal importance and these principal roads will carry a much larger percentage of the total volume of the areas traffic than the percentage of their mileage is of the total mileage of public road in the area.

Disregarding the traffic on city streets, it is generally true that one-tenth of the rural roads of a locality will carry three-fourths of the traffic. Therefore, a comparatively small mileage of road in any locality can be depended upon to carry the bulk of the transportation if the system is laid out with due regard to the traffic needs.

The volume of traffic furnishes a measure by which to test the economies of relocation and grading. A shortening of line or a reduction of grade will lessen the cost of operation for each vehicle using the road. The total volume of traffic, therefore, indicates the annual saving in operation and that is to be considered in connection with costs of relocation and grading.

Classifying the Roads.—Classification of highways according to the expected loads these highways will carry is, therefore, the logical result of traffic studies. The probable classification would be industrial, semi-industrial, and non-industrial, or light traffic roads. The industrial highways would be those carrying a large percentage of maximum weight trucks, the semi-industrial carrying a very small percentage of heavy trucks but a large number of medium weight trucks, and the non-industrial carrying principally passenger car traffic.

It is logical and it is the right of the traveling public which is substantially the taxpaying citizenship, to expect that the routes which carry the most travel will receive preferential attention.

Selecting the Type of Improvement.—The nature of traffic, that is, the amount and frequency of heavy wheel loads, practically determines the type of surface improvement. The surface to be laid should be such as will justify itself by carrying traffic at reduced operating cost and with a reasonable road cost including interest, depreciation and maintenance.

A light type surface will carry up to a certain amount of wheel load without injury, and will carry an occasional injurious load with such slight damage that the annual cost of the light type, including repairs, will still be less than the costs of a higher type surface. In some instances there are practical conditions, scarcity of funds or difficulties of construction, that retard the transition to heavy type.

Increasing frequency of injurious wheel loads, however, will, at a certain point, justify increased expenditure for surface construction, especially if consideration is given to the fact that traffic is subjected to annoyance by frequency of repairs and by the deteriorated road surface awaiting repair.

The study of the weight of the wheel loads and their frequency, as affecting type of construction, is taken into account in best practice in the province of design. An example is the formula of the so-called corner theory in which the thickness at the edge of the pavement is calculated from the formula:

$$D = \sqrt{\frac{3w}{s}}$$

Where D equals thickness at edge of pavement,

w equals rear wheel load;

s equals working unit stress in the concrete.

When wheel load w is repeated a large number of times during the day the working stress s should not exceed 50 per cent of the modulus of rupture of concrete. The modulus of rupture may be taken at 700 lb. per square inch. When heavy wheel loads are repeated infrequently, say not more than five times per day, the working unit stress might be allowed to equal three-fourths the modulus of rupture. The center thickness d is calculated from the formula:

$$d = .7 \times D$$

Determining the Width of Pavement.—Traffic largely determines the extent of road surface to be provided. This is the heart of the traffic problem. The essential characteristic of the public road is that it is open to the public and the traffic demand is for roads of adequate carrying capacity.

Preliminary to the consideration of the question of carrying capacity, there are five important conditions:

First. Within reasonable limits the public is free to enter and use the road at discretion as to points of entry and departure, and as to direction and speed of travel. As a general rule there can be no supervision over routing (no train dispatchers), and a single track cannot be made to serve the purpose of a double track by the addition of occasional turnouts.

Second. A conglomeration of freight and passenger business which tends to cause confusion and congestion must be permitted.

Third. At the present time, there is not the effective apprenticeship or control over highway drivers such as the railroads provide for their locomotive drivers and the fallibility of automobile drivers must be accepted as a road condition that increases the required factor of safety and lessens the real capacity of the road.

Fourth. It must be assumed that the time of the traveler is valuable and he must not be needlessly delayed.

Fifth. Road hazards must be eliminated as far as possible and minimized when they cannot be eliminated.

If we were free to assume that motor traffic could be handled in continuous lines spaced only with respect to avoiding danger of ramming when one vehicle in line might slow down or stop, and if we could bottle up traffic and disregard road delays, the carrying capacity of our two land highways would be so great that there would be very few cases that would involve extra width roads.

According to a Pennsylvania computation which checks sufficiently close with Los Angeles observations, a single line of traffic with the vehicles moving at from 10 miles per hour to 30 miles per hour, and spaced at intervals increasing with the speed, sufficient to avoid risk of ramming, might run 2,000 to 2,400 vehicles per hour, say 50,000 vehicles in 24 hours. Then the two lanes of a double lane road running full would have a carrying capacity of 100,000 vehicles per 24-hour day. These figures actually bear only remote connection to practical figures of annual daily average.

The characteristic advantage of highway transportation is the freedom of a driver to overtake and pass a slow moving vehicle, and the preservation of this favorable feature of highway traffic without sacrificing safety of operation sets the practical limit on carrying capacity.

In order to permit constant passing the total number of cars on a 2-track road should not exceed the theoretical capacity of a single lane, that is to say, a 2-lane road should not carry traffic exceeding about 2,000 vehicles an hour.

A general condition as demonstrated in Pennsylvania is that the roads carry the greatest volume of traffic Sunday afternoons in late July and early August.

We cannot expect a full hour of uniform flow of maximum traffic without some congestion, but it would not be practical to build for unusual conditions or for occasional peak loads, and it is to be understood that our roads must be expected to carry occasional brief overloads such as on Sunday afternoons in summer and on special occasions such as county fairs, automobile races and football games.

In addition to the variation of traffic occurring from hour to hour, from day to day, and from season to season, there is a natural change, an increase in volume, of traffic approaching the cities. The name "trunk" applied to our principal roads is very apt.

Approaching cities, branch roads intersect and traffic converges and grows in volume. Hence it may be necessary to increase the width of the road to carry the increasing traffic. For example, the Lincoln Highway approaching Philadelphia is 18 to 20 ft. wide to Downingtown (about 30 miles from

Philadelphia), 30 ft. wide between Downingtown and Paoli (about 15 miles from Philadelphia), and 40 ft. wide between Paoli and Philadelphia.

Four lanes permit segregation of slow travel to the outer lanes and unimpeded use of the inner lanes by rapid travel so that a 4-lane road may be said to have a capacity of 4,000 vehicles per hour or 12,000 vehicles annual daily average, plus whatever slow travel may occur, usually 10 per cent to 20 per cent additional.

Adding one lane width to relieve congestion of a 2-track road is not looked upon with universal favor. There is some ground for the criticism that the use of a middle path for passing from either direction involves risk. Practically, however, some roads are liable to occasional crowding of one-way travel and the three-lane road may be a very serviceable transition between two-lane and four-lane width.

Car Mile Costs.—The effect of traffic on maintenance costs is important. In general, maintenance and repair of road surfaces are necessitated by traffic and weather. With most types of surface, a certain amount of traffic is a preservative rather than a destructive agent. On an earth, gravel, or stone road, light traffic will keep the road from heaving.

Bituminous binders will retain their life, that is, their elasticity, longer if they are under compression at moderate intervals than if they are permitted to lie dormant. Even in the case of hard surfaced roads a certain amount of weight of traffic is helpful in reducing, in some cases it cannot eliminate but will alleviate, subgrade upheaval and temperature expansion.

The amount of traffic that is beneficial to various types of road surface under different conditions is not known definitely but it is generally a small percentage of the volume of traffic that the particular type of road will carry economically, so that in practice we are accustomed to consider that maintenance costs increase with the volume of traffic. Records in Pennsylvania show maintenance costs increasing with volume of traffic for all types except hard surfaces. Our hard surfaced roads are comparatively new and so far do not show sufficient wear to determine relative effects of varying volume of traffic.

The final measure of costs is the vehicle mile or ton mile. Including allowance for depreciation and interest on the costs of construction as well as maintenance and repair costs, a number of sections of road in Pennsylvania on which we have investigated show with fair consistency vehicle mile costs ranging between a fourth and a half of a cent.

Highway economies have not reached a stage where we can say definitely what constitutes the best practice in this respect, but there is a certain apparent advantage to be gained by combining the two units of traffic, passenger and freight, and using gross tons of freight vehicles with approximate weight equivalents of passenger vehicles.

There is a considerable difference in the tire equipment of these two classes of vehicles, but a balancing difference in speed, so that gross weights of passenger and freight vehicles can reasonably be combined for general study.

This usage offers the advantage of brevity and convenience over the use of combinations of passenger and truck figures. Whatever form of expression is used, the vehicle mile cost, or ton mile cost, is a figure that is of great interest in connection with problems of selection of type for improvements.

Special Features of the Traffic Problem.—The development of an improved road system in any place attracts and develops traffic. People will travel longer distances if necessary to ride on improved roads and established businesses will be increased and new businesses encouraged by comprehensive improvements. The improvement of a road always brings an increase of travel, occasionally an increase far beyond anticipation, and may bring a kind of traffic not previously known to the locality.

A class of traffic that has already reached significant proportions on some of our roads and promises to become an increasing factor in the future is the commercial vehicle operating under the jurisdiction of the State Public Utilities and Interstate Commerce Commissions. This class includes interurban passenger busses and common carrier freight trucks. These increase the number of vehicles that are of much greater weight and body dimensions than the average passenger car, and they are more seriously affected by sharp curves and steep grades, so that they are a factor in the design of surface and furnish additional reason for reducing curvature and gradient. They very often travel at a lower rate of speed than the individual passenger car prefers so that their greater body dimensions complicate the passing problem at times.

The public roads are provided for the public use and it is not proper to restrict the use of the road except insofar as the public good definitely requires. Accordingly, the weight and dimension limitations on vehicles are very liberal and the large size vehicle and the heavy load are constantly becoming of greater importance especially in the vicinity of our larger cities.

In some cases it is necessary to curtail the privileges of the individual for the good of the public. Reckless driving and obstructing traffic are both such grave infringements on the rights of others that they cannot be permitted on the public highways. Accordingly, it has become general practice to formulate regulations and enforce them by means of a motor patrol.

Each state establishes its own laws. Through the Association of Automobile Registrars uniform practice will eventually be worked out. The principal features of the laws are now practically universal, a maximum speed limit governing except in certain zones which are posted for reduced speed, no parking with all four wheels on road surface, no parking on curves or hills, no passing on curves, hills, or at road crossings, no glaring headlights. To increase the carrying capacity of roads and in an attempt to reduce accidents due to passing, minimum speed limits are being established in some states.

Present day traffic conditions have made "Service and Safety" the watch words of the highway departments. In 1917 there were 9,097 automobile fatalities; in 1920, 11,074; in 1923, 16,452; in 1925, 19,828. It is true that the fatalities in ratio to registrations have decreased from 178 per 100,000 in 1917 to 100 per 100,000 in 1925, but the actual number of accidents is more important than registration ratios. In addition to fatalities there are many accidents in which persons are uninjured. In Pennsylvania in 1925 the number of accidents reported on state highways was 1,666 with a toll of 135 killed and 1,501 others injured.

Highway Marking.—The so-called "tourist traffic" has become a perceptible percentage of the total travel.

For this reason, and also because if we build, mark and maintain our roads in such a way that we furnish complete and safe service to the visiting driver, the local driver will unquestionably be provided for, the Pennsylvania practice is to plan for the visiting driver.

Telephone poles along state highway routes are whitewashed, all routes numbered, marked conspicuously on the road and on maps that are available for distribution. Substantial direction signs are placed at intervals along the road and where temporary detours are necessary, they are marked and each week maps showing what detours will be in use for the following week are circulated.

Substantial roadside signs are placed to provide warning for curves, steep hills, railroad crossings and road intersections.

Supplementary warning signs are painted on the pavement for railroad crossings, road intersections and steep hills. Traffic line is painted along the center of the pavement at railroad crossings, road intersections, at curves and on hills, and no passing or parking is permitted in the zone of the traffic line. Reflector signs are provided to furnish warning for drivers at night. Railroad grade crossings, narrow bridges and all road obstructions are being eliminated or safeguarded as rapidly as possible.

Snow Removal.—The most striking example of traffic service is in snow removal. Pennsylvania's handling of this problem illustrates present prac-

tice. The principal routes (about one-half of the mileage) of the state system are designated as the "Snow Removal Program" and the orders are that these roads be kept continuously open.

Additional main roads may be opened but may not interfere with keeping the Program roads open. Truck and tractor equipment, moldboard plows, V-plows and rotaries are distributed and with operators are held in readiness for duty in heated garages in each of 52 maintenance districts.

Snow is removed from the entire road surface and from an 18-in. strip of shoulder along each side of the road. Hills that become slippery are covered with a scattering of stone chips or cinders.

The purpose is to take care of the traffic, as it comes, in such way that the driver, whether or not he is familiar with the locality and road, need only exercise reasonable care to be assured of reaching his destination with a safe, comfortable and expeditious trip, the every-day solution of the traffic problem.

Code of Ethics of Ontario Road Contractors

Highway contractors of the Province of Ontario, Canada, have formed a new organization to be known as the Ontario Road Contractors Association. At this organization meeting, on Feb. 23, the following code of ethics was adopted:

To the Engineer:—He is a representative of a profession that for long ages has borne worthily a reputation for superior skill, sound judgment, high accomplishments and unimpeachable integrity. Until by his own action or words he forfeits my appreciation, I shall assume that the engineer under whom I am a contractor is a worthy representative of his profession, and shall treat him as such. I will in letter and spirit co-operate with him in the conduct of the work to a satisfactory conclusion. If I find his designs in error so as to cause failure to the work or serious loss to the principal, I will, in a fair and courteous manner, inform him before extra and unnecessary cost has been incurred. If the work does not progress in amity, I shall be sure the fault is not with me.

On the other hand, I shall maintain the dignity and responsibility of my own position against all unwarranted actions or demands, without fear or malice, but with full determination to secure my rightful dues.

To the Principal:—My principal in all public works is the people in the persons of their duty elected or appointed representatives. From the positions they occupy, I must assume that all such persons enjoy the confidence, possess the necessary qualifications and bear loyal allegiance to the public interest they represent.

It is their responsibility to decide and design the works that shall be constructed by and for the people; where, when, and how.

My privilege is to contract for their construction and it is my duty to execute with honesty, efficiency, and dispatch, any contract awarded to me.

It is my right to expect the elimination of unfair or onerous provisions, restrictions, or regulations of the engineer which, if continued, tend to render the work unnecessarily costly to the principal or unprofitable to me without commensurate benefit in the quality of the work.

To My Brother Competitors — To Every Other Contractor: — He has troubles of his own—just like mine. He has the right to exist and to undertake contracts—just like me. He is hurt and offended when subjected to misrepresentations, slanders, petty larceny of his valuable employees, or grand larceny of any contracts rightfully his, just as I am. I cannot expect him to spare me if I be guilty of any such practice. Therefore I will scrupulously refrain therefrom.

I will not dishonestly or ignorantly disparage the personal character or the works of my competitor to anyone for any reason, nor carelessly for no reason. This pledge shall also bind me not to similarly overrate his qualifications to the detriment of principals, other contractors, or myself.

I will refrain from causing him loss or embarrassment by deliberately attracting from him any of his employees.

I will not knowingly bid too low a price with the deliberate intention of causing my competitor loss, but only such a price as I am willing and ready to accept for the faithful execution of the contract myself. Having bid honestly, I will not unfairly reduce my price to secure a contract away from any other contractor. I shall, however, be free to maintain by all fair means any superior claims I may have that the contract should be awarded to me at my higher price.

To My Employee:—I shall be fair and just to my employee, and refrain from taking any improper advantage of his weaknesses, poverty, or dependence. I shall encourage him to improve his status by fitting himself for higher duties. I shall encourage him in the proper discharge of his debts to his creditors and the proper maintenance of his family. I shall demand from him industry, efficiency, and undivided loyalty.

To Myself:—I have adopted contracting as my vocation. I have invested my time, energy, and money in this vocation. I shall seek to improve myself, my organization, my equipment, and my methods so that I may the more efficiently, satisfactorily, and profitably conduct my operations. If by so doing I am able to secure a larger profit on my work than my less efficient competitors, it is ethical for me to retain such profits. It is also ethical that I should share prospective profits on future work with my principal by submitting such decreased prices as my greater efficiency makes possible. Providing always that I owe it to myself and to all the other relations specified therein that I bid so as to secure a fair (or plus fair) profit on all contracts for which I accept the responsibility of satisfactory execution.

Sand-Clay Surfacing in North Dakota

The method of sand-clay construction used by the North Dakota Highway Department is described by J. E. O'Neil, Construction Engineer of the Department, in the North Dakota Highway Bulletin, as follows:

In the construction of road throughout portions of the state where lighter soil is encountered, it is sometimes found that the natural soil is too sandy to compact properly under traffic and in some cases it is not deemed advisable to place gravel on such loose, sandy subgrade as the gravel under heavy traffic mixes with the sand subsoil and therefore will not compact and in a short time is an entire loss. In such instances, it is found practicable to place a clay mat of from 2 to 4 in., depending upon the amount of clay or binder that is contained in the subgrade, and after placing the same it should be properly mixed by means of double plowing, discing and harrowing until the entire top is thoroughly mixed. Traffic is then kept off the road until the surface is thoroughly wet down, puddled and shaped. From our experience with sand and clay surfacing, we believe that the thorough mixing of the materials is the secret of the success of sand-clay surfacing. Where such material is not thoroughly mixed, small patches compact and the portions immediately adjacent pocket out thereby leaving a rough and hard riding surface as well as a road that is almost impossible to maintain properly until such time as the entire surface is scarified and remixed.

Before deciding on the amount of clay necessary, a comparative sample is taken of the portion to be surfaced, this sample is tested and the amount of binder it contains is thereby determined. Samples of the clay to be used are also tested so as to determine the amount of sand contained. It is then mixed in proportion so that the entire mix shall contain approximately 30 per cent clay. This type of surfacing has been found to stand up well under fairly heavy traffic for a season or two and still be in shape to hold gravel surfacing without any of the sand working up and mixing with the gravel material.

Maintenance of State Roads in Missouri

Policies, Organization, Personnel, Equipment, Accounting and Work Accomplished Described in Biennial Report for Period Ending Dec. 1, 1926, of State Highway Commission

Maintenance of state roads was inaugurated in 1923, immediately following the adoption in November, 1922, of the amendment to the state constitution authorizing the use of a portion of the automobile fees for maintenance of state highways. From a modest beginning, this work has expanded and grown by steady and logical steps until there is a well organized and trained force of nearly 900 men, fairly well equipped to render efficient service to the traveling public.

The biennial period of 1925-1926 was begun with two years' experience in the background and a limited amount of equipment on hand. The construction program had advanced to a point where the worst and more troublesome sections were rapidly being eliminated. These facts, together with the additional funds provided, enabling the department to make real progress in better serving the traveling public.

Particular attention was given not only to keeping the constructed state and federal projects and the temporary roads in proper repair, but to their betterment where possible. To obtain this objective, special time was devoted to perfecting the organization, to improving the systems and plans of operation, and to the securing of more economical and satisfactory equipment. A close study was made of the systems, organizations, methods of operation, control of expenditures, etc., in use in other states which had older and more advanced organizations. The more desirable, tried, and successful features as gleaned from the study of other states were gradually adopted and molded to our needs.

As a result of systematic and careful study and work, satisfactory results have been accomplished during the past biennial period. During the previous period, complaints were numerous; whereas, during present period, complaints received from the traveling public have been but few, even during the very unfavorable wet seasons, as experienced in the fall and winter of 1925 and the early fall of 1926.

Maintenance is defined as being the immediate service rendered to the traveling public by the keeping up of road service, by providing conveniences and safety devices for traffic on both improved and unimproved state roads, and by affording protection for the investment made therein. Money spent for maintenance gives quicker returns on the investment than any other expenditure made for highway work. Accordingly, money properly and economically spent for maintenance meets with instant and popular approval from the traveling public.

Policies.—The general policy governing all maintenance work is to render the greatest possible service to the traveling public with the funds available. This service consists of first remedying, at the earliest possible time, unusual situations which block or impede traffic; second, by providing for the repair and maintenance of sections built by state and federal aid; third, of directing efforts to the general improvements and maintenance of all temporary and permanent state roads.

Service to the traveling public requires that the motorist be directed on his way with the least inconvenience possible and also that his journeys be safeguarded. This requires all the highways to be carefully marked as to route, with sufficient warning signs at danger points, and information signs where needed. The policy of the department has been to give this service to the fullest extent possible and to co-operate with the federal government on the marking of the U. S. highways through the state.

As rapidly as construction work is completed on sections of the road, they are taken over by the maintenance bureau and kept in good condition. The unimproved portions between projects, also the detours around construction, are maintained in as serviceable a condition as the funds available will permit. Constant attention is given to the bad mud holes and they are eliminated as completely as possible. These obstacles are becoming fewer and fewer on our state roads.

The worn-out and unserviceable sections of the constructed roadway are repaired and replaced as rapidly as they deteriorate under the action of traffic, every effort being made to prolong their life and serviceability. Maintenance, therefore, insures the state against the loss of money invested in road construction.

Organization.—To perform successfully the tasks set out in the policies of the highway commission, the giving of efficient service on the 7,640 miles of state highways, has required the employment of a large force of men over the whole state. The engineer of maintenance, working under the direction of the chief engineer, and in accordance with the policies of the state highway commission, has active general supervision of all maintenance activities in the state.

The state-wide maintenance organization was built up on business administrative lines, using the established subdivisions of the department for delegating authority and fixing responsibility.

The state had already been divided into ten divisions with a division engineer in charge of each division to handle surveys, plans and construction activities. For the sake of efficiency and co-ordination, the division engineer was made the directing head of the maintenance work in his division, subject to instructions from the engineer of maintenance, working under the direction of the chief engineer.

The supervising maintenance engineers, assisting the division engineers in their tasks, are delegated with full powers necessary for efficient leadership, and they superintend all the actual maintenance activities in the field. They are assisted in their office work by a maintenance clerk and stenographer.

The divisions are made up of ten or eleven counties, and each division contains from 600 to 800 miles of state highways. At the inception of the maintenance program, the county was recognized as the next subdivision, and a county superintendent was put in charge of each county. He was made responsible for the condition of all the roads, equipment, supplies and materials within his county, and he superintends the work of the patrolmen in the county.

The mileage was divided into sections of varying lengths, depending on the topography of the country, character of the soil, type of surfacing, and class of machinery available. Patrolmen were appointed to maintain these sections of the road. The necessary equipment to carry on the work was assigned to each as rapidly as it could be acquired and the patrolman was made responsible for its condition and proper use.

The rapid progress of the surfacing program thereby constantly changing the type of road being maintained, has required a change in our organization. Gang patrols were assigned to long sections of pavement of the same class. This often threw a patrol in two counties under two county superintendents. This was not a satisfactory arrangement; therefore, in many instances, it was necessary to abandon the county as a unit and lay out districts, composed of two or more counties or parts of counties, with a foreman in charge.

This has proven a satisfactory and much cheaper form of organization. The district foreman who has generally been promoted from the ranks of the county superintendents, has been trained in the use of various classes

of equipment, and is familiar with two or more types of surfacing. This especially qualifies him to direct the patrolmen in their duties, to keep the maintenance machinery in his district in operation and to keep the roads better maintained at less expense.

Funds.—Money spent for maintenance gives quicker returns on the investment than any other expenditure for highway work. When the money is available, there apparently is no limit to the improvements that can be accomplished on a road through continual proper maintenance. All highway maintenance programs are limited by the amount of money available.

The legislature of 1925 appropriated $4,150,000 for the biennial period of 1925-1926 for maintenance purposes. This gave the department $2,000,000 a year to cover the expenses of maintenance operations on the 7,640 miles of state highway, and provided $150,000 for reconditioning equipment, supplies and tools which were rented or sold to contractors, counties and special road districts and used for road work. Such revenues as were derived from these sources were deposited with the state treasurer to the credit of the road fund.

Insofar as it was practicable, the available funds were so apportioned to each county as to make the entire mileage on all designated state roads not under active contract, most serviceable to all the communities served.

Personnel.—The perfecting of the organization necessary to the successful execution of a maintenance program is a task requiring patient effort and persistent co-operation of all the employees. Whatever success is attained is due to employing competent and reliable men who will give efficient service in the performance of their duties.

Considerable care has been used in choosing all maintenance employees, with an eye for efficient service. Special effort was used in selecting the supervising maintenance engineers. The majority of these men have been appointed from within the department and were obtained from the the field and construction forces. Those men chosen from outside had all been engaged in highway work for a number of years, particularly as county highway engineers in this state.

Each man in the subordinate positions was chosen with the same care. The selection was made from his outstanding fitness for the position in question. An attempt was made to choose our men according to physical ability, character, alertness, judgment, and past record. Local men were used whenever possible.

All county superintendents, district foremen and patrolmen are required to give a personal bond for $500, which insures the state against unreliable men.

The employment of relatives of men already at work for the department has been avoided as much as possible. Whenever vacancies occur in the organization and it is possible to do so, these vacancies are filled by promotions of the men most fitted for the place.

The following is a list of the employees of the department, arranged by several groupings to show their distribution and rates of pay of each class:

Bureau of Maintenance—Number of Maintenance Employees, November, 1926

Classification	Total No. Employees	Aver. Salary Under Each Classification Per Month
District foremen	25	$148
County superintendents	46	133
Assistant county supts.	4	126
4-horse-team patrol	67	138
3-horse-team patrol	15	121
2-horse-team patrol	201	112
Tractor patrolmen	126	90
Truck patrolmen	146	89
Patrolmen	31	95
Patrol helpers	116	80
Gang foremen	5	138
Garage foremen	9	159
Mechanics	12	132
Traveling mechanics	6	134
Mechanic helpers	3	111
Sign shop helpers	2	100
Markermen	10	92
Tractor operators	13	120
Grader operators	12	128
Blacksmiths	1	130
Carpenters	1	105
Marker foremen	3	130
Painters	1	160
Total	855	

Equipment.—The purchase of all new equipment used in the maintenance of the system is handled through the main office.

When equipment was purchased in any quantities, simultaneous quotations were asked of those firms interested. The various concerns manufacturing such equipment were requested to submit prices and discounts in writing, and selections were then made according to prices, together with type and character of equipment desired. All companies were further required to file price lists of repair parts which were taken into consideration, together with above. Also, an effort was made to confine purchases to standard equipment which had been on the market long enough to be thoroughly tested and which was manufactured by firms fully reliable and in position to give service on parts.

In general the purchase of equipment has been confined to small amounts as the need for same developed in the progress of completion of the system. Firms interested in furnishing equipment were required to file prices and discounts in writing, from which prices were compared and selections made according to type of equipment desired. The various types of road surfacing, soil conditions, volume of traffic and local conditions must be given consideration, along with the service to be obtained, when selecting equipment.

When materials and supplies, such as culvert pipe, grader blades, drag blades, marker, signs, lumber, and other material which could be clearly specified and defined were required, sealed bids or quotations were asked for and the order awarded to firms submitting lowest bids. This policy has resulted in a vast saving to the department.

The bureau is continuing to make use of the available war equipment, such as government trucks, tractors, etc. The use of certain government trucks for maintenance work, especially for tractive power, is not essentially economical; but must be practiced, pending replacement, until the necessary funds become available to purchase more economical power. Wherever possible, through accumulation of small surplus of funds, these war trucks are being replaced with more economical maintenance units.

The following is a list of the equipment at present in use by the department:

Graders and maintainers	635
Asphalt heaters	53
Asphalt heater and distributor	1
Lime mashers and center stripers	11
Water tanks	2
Disc	2
Rollers	5
Air compressors	3
Concrete breakers	3
Jack hammer	1
Gravel plants	5
Gravel elevator	1
Sweeper	1
Concrete mixers	4
Crushers	5
Seed drill	3
Harrow	5
Mowers	33
Snow plows	5
Scrapers	624
Fresnos	28
Plows	168
Loadometers	4
Tractors	219
Trucks	396
Automobiles	49
Gas engine	1

Maintenance Accounting.—To enable the main office to definitely control the expenditures and to keep in touch with field conditions at all times, the biennial period is divided into four allotment periods of six months each.

Every six months the main office allots to each county a certain amount based on the mileage of state highways in the county, the type of roads, soil conditions, traffic, etc.

Before any expenditure is made, each division office is required to submit to the main office an authority for expenditure, setting out in detail the amount contemplated to be used in the county for a six-month period. A certain amount is reserved for the purchase of equipment, and for unforeseen conditions, such as floods, heavy snows, etc. When this authority for expenditure is received and approved in the main office, the division engineer is given notice to proceed under the conditions outlined in the authority for expenditure.

When the purchase of supplies, labor, etc., in small quantities is contemplated by the county superintendents or patrolmen, they are required to submit to the division engineer requisition for their purchase, and this requisition is approved by the division engineer before purchase is made.

County superintendents and patrolmen are required to submit weekly reports to the division office showing by days the nature of work done, location,

equipment and tools used, miles operated, detailed motor reports, material and supplies used, etc.

These reports are distributed upon special forms in the division office and are used as a basis to check invoices and labor for payment.

Monthly material and labor pay rolls are made up in the division office and submitted to the main office where they are thoroughly checked against the authority for expenditure before forwarding for payment.

All purchases for equipment are made through the main office on purchase orders approved by the chief engineer.

Insofar as possible, all expenditures are charged to a section of road. Expenditures not chargeable to a section of road are charged to a county for later prorating. This system enables us to obtain detailed cost data on maintenance of various types of roads.

Miles of Various Types Maintained

	1925	1926
Brick and concrete	540	1,108
Bit. and penetration macadam	337	569
Gravel	1,549	1,676
Graded earth	1,160	1,073
Unimproved earth	3,157	2,519
Detours	790	725
Totals	7,535	7,672

Statements are made weekly of all orders for equipment or materials and requests for authority for expenditures. Detailed statements of expenditures are compiled monthly.

Actual field inventory of small tools and equipment is made annually by inventory clerk from the main office and each county superintendent or patrolman is held accountable for all tools or equipment assigned them, under the conditions set forth in their bonds. Each and every maintenance employee is under a $500 bond to guarantee a strict performance of his duties and for the proper care of his equipment.

General Work Accomplished in Biennial Period.—During the biennial period the maintenance forces have dragged and kept in as good repair as possible with the funds available, a total of 7,671 miles of roadway, including detours around construction. One of the accompanying tables shows the number of miles of various types of roads maintained in 1925 and 1926.

Weather conditions have not been ideal for road work during past two years. The fall and winter of 1925-1926 were extremely wet. A heavy snowfall was witnessed late in March, 1926. As a result of this the spring of 1926 found roads in a deplorable condition. This was true especially of dirt roads, but other roads failed to escape entirely. Over north central and west central portions of the state, torrential rains began early in September, 1926, and did not cease until the seasons' work by maintenance forces was practically eliminated.

As soon as weather conditions permitted, every effort was directed to repairing the damage done, and at least making roads reasonably passable for the winter.

Considerable work of additions and betterments to the roads of the system has been accomplished by the maintenance forces during the biennial period. This work was performed conjointly with that of routine maintenance and under the direction of the full time employees. Extra laborers, teams and equipment were used to assist in this work.

Following is a summary of the addition and betterment work accomplished:

Heavy grading on temporary routes, including widening and other semi-permanent work	1,462	miles
Light grading on state projects and improved temporary routes, including reshaping roadway, cleaning ditches, etc.	3,184	miles
Earth roads gravel surfaced	288	miles
Gravel used on above	93,670	cu. yd.
Gravel roads resurfaced	305	miles
Gravel used for resurfacing	57,065	cu. yd.
Roads, surface-treated with bituminous material	60	miles
Bridges cleaned and painted	43	miles
Bridges refloored	14,504	lin. ft.
Bridges built or replaced (all types)	79	
Small culverts built or replaced	632	
Large culverts built or replaced	103	
Temporary guard fence built	12,615	lin. ft.
Guard fence repainted	255,531	lin. ft.

Certain sections of the system which had been forming obstacles to the passage of traffic in counties where the construction fund allotment was insufficient for permament improvement, have been improved by the maintenance forces and paid for out of construction funds. In a few cases the improvement consisting of clearing and grubbing of the right-of-way, constructing semi-permanent and permanent drainage structures and the grading of the roadway with heavy gang maintenance outfits. In other cases the roadway was graveled by the maintenance forces.

Jay Walking Retards Traffic

Jay walking as a pedestrian pastime is a losing game, according to scientific traffic studies made by the Albert Russel Erskine Bureau of Street Traffic Research, which has found that the pedestrian who ignores traffic signals and rushes across street intersections without their protection has less than one chance in three of reaching the other curb without wasting more time than he saves.

A study of the walking habits of more than a million and a half people, which forms part of the report of the Chicago Street Traffic Survey made by Miller McClintock, director of the Erskine Bureau, confirms the warnings of safety experts that the jay walker seldom saves time by his infraction of traffic rules. Results of various checks made at typical street intersections showed that more than half of the pedestrians held up by movement of cross traffic attempt to break through the traffic stream against the signal lights, but that only approximately one-third of those who make the attempt are successful in reaching the opposite curb. The rest are caught between moving lines of traffic in the center of the roadway, endangering themselves and materially reducing the speed and volume of traffic flowing through the intersection.

Other studies made in Chicago's "loop" business district developed that the pedestrian tendency to jay walk results in a serious retardation of the speed and volume of traffic movement. Intersections capable of carrying two lines of traffic safely at a speed of fifteen miles per hour are often reduced to one lane moving at a speed of ten miles an hour.

The importance of the street intersection is obvious when it is realized that the intersection is the key to the problem of traffic congestion on any busy street. "The streets can carry no more traffic than can be passed by the intersections," says the survey's report. "Thus if the capacity of the intersections is reduced fifty per cent by pedestrian interference, the streets can carry no more than half their full capacity."

"Reduction of traffic capacity is not to be found only at the intersections, where conflicts exist between pedestrians, but in mid-block as well," the report continues. "Motor vehicles cannot move safely when at any moment pedestrians are likely to appear in their path.

"The amount of this type of mid-block interference is not generally realized. Counts at a number of locations in the central "loop" district showed that during the noon hour, 12 to 1 P. M., the number of pedestrians crossing at places other than at the intersections numbered more than 1,000 per block." Near State and Madison Sts., whose intersection makes the world's busiest corner, nearly double this number left the sidewalks to mix with and delay motor traffic in the middle of the block.

To reduce the congestion and waste of time occasioned by this one phase of the traffic problem the report of the survey recommended that jay walking be prohibited, with suitable penalties for violation—jay walking being defined as the practice of pedestrians crossing other than at street intersections.

In order to reduce the inconvenience of pedestrians to a minimum and to introduce a degree of flexibility into the rule, the report also proposed that crossings be placed near the middle of blocks in districts where the distance between intersections exceeds 400 ft., and that in such cross walks pedestrians be permitted to cross with a right of way over vehicular traffic.

Cost of Collecting Gasoline Tax.—Figures compiled by the Vermont State Chamber of Commerce show that in 1925 the average cost for collecting the gasoline tax was $2.64 per $1,000 collected, or $65 per 1,000,000 gal. taxed. These figures are the average for 21 states.

Inspection of Concrete Structures

Suggestion for Bridges and Culverts Given in Paper Presented at Annual Conference of Ontario County Road Superintendents

By JOHN EMPEY
District County Road Engineer, Department of Public Highways, Ontario

In the construction and inspection of concrete bridges and culverts, the following precautions should be taken in the preliminary work where plans are necessary:

See that new culvert or bridge is located in proper place. The best location is the one that gives the best and most direct access to it and allows the quickest flow away from it again.

Make sure of ample size.

Make sure that culvert is low enough.

See that footings are fully excavated. as to proper depth and full width with no corners or angles overlooked and left in.

See that footings are put down to good foundation.

Culvert and bridges, where possible, should be located at right angles to direction of the road and center of culvert should be in center of right-of-way.

Culverts, where possible, should be sunk low enough so that there is at least a foot of earth over the slab.

All water should be removed from trench before concrete is placed into it, and concrete should never be shovelled or poured into water.

Concrete Materials.—Where gravel is used care must be taken that it is free from loam and vegetable matter. No top soil or other foreign matter should be allowed to mix with it.

Materials should be of proper combination of sand and stone. Always avoid an excess of sand and there should be plenty of stone aggregate up to 2½ and 3 in. in diameter if we are to obtain good strong concrete.

Where gravel contains excess of sand either mix with crushed stone or screen out excess sand.

Water used to mix concrete should be clean and pure, free from mud, silt or alkali.

Cement should be matured but not caked or exposed to moisture so as to become hard.

Sand should be sharp and coarse and free from silts, etc., and gravel should be free of slate and soft stone.

Preparation for Placing Concrete.—See that ingredients are mixed in proper proportions. This also refers to proper amount of water used in making concrete. If concrete is made too wet we do not get as strong a concrete. A rough test is when you can squeeze a handful into a rough ball.

See that forms are set up in accordance with plans having proper distance between two sides to give required thickness of walls, slab or copings at different points, and walls plumb.

See that forms are well braced and tied together so that they remain rigid and do not slip or move else concrete will not be of uniform thickness and the surface will not be smooth and straight.

See that surface of lumber is smooth, free from dirt or coatings of old concrete.

Surface of forms, against which new concrete is coming, should be oiled with cheap oil to prevent undue absorption of water from green concrete, otherwise water will be absorbed before concrete sets and surface will be rough and powdery.

Placing Concrete.—In pouring concrete into forms, care should be taken that clay or other materials are not dropped into the trench or knocked off the bank into the concrete, because these lumps of clay are not only weak spots in the concrete, but will absorb moisture, swell and cause holes to break the surface. Care should also be taken that workmen in picking up the gravel to put into the mixer do not shovel up particles of clay or soil from the ground where gravel is piled.

Concrete should be well spaded into space in forms, care being taken that it is puddled well against the forms at all points. This latter action prevents pockets of water forming in green concrete which become holes and openings into the concrete when it sets and dries.

Where it is not possible to complete the mixing and pouring for the whole structure at same time or in same day, the surface of the concrete, previously poured and to which a bond is desired, should, when operation is started the next day, be treated with a wash of one of cement and two of sand. Also at the end of the day's work if on walls, plums of clean stone of such size as wells will permit, should be partly submerged into concrete so as to give bond to subsequently poured concrete. If stone is not available, bond may be obtained by sticking short lengths of 2 by 4 or 2 by 6 edgewise into concrete and removing before concrete is fully set.

Slabs of culverts or floors of bridges should be completed at one pouring if at all possible.

Bridge Floors.—Care should be taken in constructing concrete floors on bridges that there is a slight crown in roadway and vents at side should be made in concrete to allow surface water, after rain or thaw of snow, to drop through to the stream and not have pools of water lying upon the bridge floor.

In laying floors on bridges great care should be taken, at one end at least, that there is no bond between floor and abutment, that floor has plenty of opportunity to move, due to expansion and contraction from change in temperature, without pressing against any part of the abutment to injure it or to move it out of alignment.

Where there are any concrete beams or steel work used in culverts care should be taken to prevent concrete from being daubed over the surface of these, and if this occurs, concrete should be removed after construction work is completed and steel repainted.

Where earth is removed to put down footings, care should be taken that all surplus materials are removed from bed and banks of stream. This material can be used to backfill, if of good material, or can be used to widen grade of road in approach to bridge.

Care should be taken that backfilling is properly done, that all pockets and spaces are rammed full of good materials. Sometimes it is good practice to sprinkle the earth as it goes into the fill.

Mistakes to Avoid.—It is my firm belief that one of the greatest mistakes in making concrete structures and pavements is in that materials are not properly mixed, by that I mean, that they are not stirred and mixed one with the other sufficiently before they are placed in the structure. The cement is the binder in the concrete. It acts like the glue holding two pieces of wood together and if all the particles of sand and stone are not thoroughly coated with cement we cannot hope to have proper adhesion of particles and the result is poor concrete, easily broken or worn away. Be sure that materials are mixed properly. In a mechanical mixer each batch should be mixed at least from 80 to 90 seconds.

Where it is necessary to get plans from an engineer, the engineer should go upon the ground and secure his own information and data to prepare the plans. The superintendent should be on the ground all the time while work is going on and see that foregoing details are carried out, or have some one he can fully depend upon there as his representative, and in case of contract, the superintendent and the engineer who prepared the plans should together make final inspection of the work before the final payment is made.

All concrete work culverts should be properly reinforced with steel rods or square iron bars. These should be clean on surface, cut to proper lengths, bent to proper shapes and not allowed to project to edge of concrete to become corroded or rusted from weather.

In foundations and footings one man stones may be used as plumbs and fillers, but none of these should be allowed to come nearer to each other or surface of walls than 3 to 6 in. and the surface of them should be thoroughly cleaned before placing in concrete.

Director-Manager Government for Utah.—A bill is now before the Utah legislature providing optional director-manager government for cities of the first class and for cities of the second class of 30,000 population and over.

A Diversity of Paving Around Chicago

Short Survey of Work Shows Various Methods in Use on Street Paving Work in Cook County, Ill., and the Use of Granite Block, Asphalt, and Two Types of Concrete as the Kinds of Pavement Suited to Modern Traffic Conditions

The great modern metropolitan areas such as those including and surrounding Chicago and New York are, and should be, fitting laboratories for the development of municipal paving methods to meet the requirements of changing municipal traffic conditions. What kind of paving work is now being done in the Chicago district? How is it being done? Those are questions that are frequently asked by the highway engineer and contractor from other parts of the country. To obtain the answer, a survey has just been made by ROADS & STREETS which has revealed the following interesting facts. No attempt was made to determine the total mileage of the various types of work on the 1927 program, but representative jobs were visited, all under way at the same time, and the situation at each job observed with care. Of particular interest is the fact that the City of Chicago, in paving streets under the direction of its Board of Local Improvements, is using an unreinforced eight inch or ten inch concrete slab laid in two courses, while an outlying community, in work designed and supervised by a prominent engineering firm, is planning to carry similar traffic on a slab that is a new modification of the Bates section, heavily reinforced, and laid with concrete that is mixed in accordance with the most modern ideas.—The Editor.

While Chicago has, from time to time, used many kinds of paving and her streets display examples of about every paving "period" that the middle west has ever experienced, at present the selection seems to have narrowed down to about three types of work for the majority of the contracts that are now being let. Certain heavy traffic streets, where dray traffic predominates, are paved with granite block on a concrete base. Certain boulevards are being paved with asphalt on a concrete base. Residential and business streets in outlying districts are being paved with two-course concrete. Out in the suburbs, both asphalt and concrete are used, with a predominance of the latter type. Here the concrete is mostly of the more modern one-course type, and in many towns conforms more nearly to state specifications, due to the growing practice in such communities of an engineering firm a member of which was head of the engineering staff of the Illinois State Highway Commission, and who has established himself as a leading authority on highway design and construction. Another factor effecting this choice is the fact that a number of such streets are along state and county roads, and that financial aid from state and county is contingent upon the street being paved so as to meet state or county requirements. One such example is included in this article.

Halsted Street.—Halsted Street is a north-south street a short distance west of the Chicago River and the Loop, and on the west side bisects the Ghetto; scene of the famed and noisome Maxwell Street market. This street carries two tracks of the Chicago Surface Lines, and besides a heavy traffic from this source, must provide for a motor and horse drawn traffic representing about the most severe industrial loading. Steel-tired wheels of the heaviest of horse-drawn drays and the solid rubber tires of the heaviest of trucks provide most of the punishment that the street must bear, since pleasure vehicles account for but a small part of the traffic.

This street is just now being repaved, under the supervision of the Board of Local Improvements, for the City of Chicago, by the contracting firm of John A. McGarry & Co. When the job was visited, the 8 in. base of 1:3:5 concrete was being laid, but according to Henry Fowler, a member of the contracting firm who was found on the job, the street will be further paved with 5 in. granite block with mastic filler. In laying the base, 4-bag dry batches are delivered from the yards of the Chicago Union Lime Works, located at 19th and Lincoln Streets, in two-batch O'Connell "Super" trucks. Twelve of these trucks were devoted to the job, although 14 would have been used if available. A man was stationed at this material yard to supervise the proportioning of the batches and their dispatch to the job, about a mile or so away. Concrete was mixed in Koehring 27-E steam paver, and deposited on the subgrade in the usual manner. A 16-man crew took care of this part of the work, including the operation of the mixer and the shoveling and brooming of the slab. The concrete was mixed at a consistency that required about 24 gal. of water to the batch, or about 6 gal to the sack of cement. This organization averaged about 1,400 cu. yd. of concrete a day on this job. When farther from a material yard, according to Mr. Fowler, they would have their own stock piles, batcher plants, and batch trucks. On this job, the haul from the yard that was prepared to furnish dry prepared batches was so short, he said, that it proved economical to obtain materials in this way, especially since the congested district made stock piling a problem.

The handling of the batch trucks at the mixer was done in an interesting way. The street was being paved in three strips, with two strips always open to traffic, and with the street-car tracks being paved last of all. In delivering the batches, the loaded trucks were backed onto the subgrade and up to the mixer. After the load was dumped, the driver simply changed over

Fig. 1.—Laying the Concrete Base on the Halsted St. Job

to the opposite driving seat of the truck, drove up onto the car tracks, and away to the yard, while the next truck, with the driver in the backing seat, backed up to the mixer with the next batch. The contractor was further represented on this job by C. E. Bradley, Superintendent.

Laramie Avenue.—Far out on the northwest side, Laramie Avenue was being paved with two-course concrete. This work, too, was being done for the Board of Local Improvements, this time by the contracting firm of the Hedges Construction Company. This firm was represented on the job by J. ("Jim") Slattery, foreman, while the City was represented by Ed. J. D. Ryan, engineer in charge. The work under way represented original paving on an old dirt street, and extended from Roscoe Street to Fullerton Avenue, a distance of a little more than a mile, and requiring about 28,000 cu. yd. of concrete. This propect called for an 8 in. two-course concrete slab with expansion joints at 30 ft. intervals, except for a different spacing at alleys and street intersections, together with combined curb and gutter.

Fig. 2.—Grading and Rolling Subgrade on Laramie Ave.

Fig. 3.—Cement and Aggregate Handling on Laramie Ave.

Fig. 4.—The Paving Gang at Work on the Laramie Slab

The grading on this work, done but a short distance ahead of the mixer, was taken care of by a ¾-yard heavy duty Osgood steam shovel, loading direct into heavy trucks for transporting the spoil to the dumps. Directly behind, a Huber 9-ton roller and a Kelly-Springfield (Buffalo-Springfield) 11-ton steam roller prepared the clay subgrade for the slab. Curbs had been set before grading, and the spoil from the curb trenches was thrown onto the ungraded subgrade to be removed by the shovel.

For the paving work, aggregates were delivered by truck to a paved side street near the mixer and dumped onto stock piles. Cement was delivered from the Universal mill at Buffington, Ind., on large trailers. These trailers were allowed to remain on the job until unloaded, serving as loading platforms. Three Barber-Greenes, one for the torpedo sand, one for the No. 9 gravel, and one for the No. 4 granite screenings for the top course, loaded these aggregates into Hug 32½ cu. ft. capacity dump trucks, the cement was then dropped on the load, and the batches then delivered to the paver, running around the block.

A Ransome 27-E paver was used on this job. The mix was a nominal 1:2:3½, mixed in 5-bag batches with about 22 gal. of water to the batch. A 6-in. limestone concrete base was first laid, and this followed by a 2-in. granite topping. Finishing was secured first with a perforated roller, then by long handled floats, and then came a belting. The surface was then checked by a wheeled bridge template, and wet burlap then laid. This burlap was allowed to remain in place for 24 hours, then calcium chloride was applied at the rate of 2 lb. per square yard. If rain occurred within three hours after application, more calcium chloride had to be applied. With this treatment the street could be opened within two weeks during the summer, and within three weeks for work laid after September 1.

The organization required on this job included:

4 graders, pit men
2 roller men
1 shovel operator
1 mixer operator and helper

4 cement hands
3 loader operators
8 trucks and drivers
2 center strip men
2 expansion joint men
2 cement finishers
6 laborers on concrete
2 laborers ahead of mixer
1 mechanic
1 supply truck and driver
2 receiving clerks
1 foreman
2 inspectors

Progress was made on this work at the rate of 900 to 1,300 yards a day. The grading, on which the shovel was served by 4 Macks, meant the removal of about 630 cu. yd. of dirt each day, making an average cut of about 3 ft.

Diversey Boulevard.—This street was being extended westward, and paved with concrete. Since it will later carry a double track line of the Chicago Surface Lines, some provision had to be made to provide for that work. Here the solution was to pave the street in three strips, so that the sreet-car company could later remove the center strip, lay their tracks, and repave at their own expense. Since this street would be expected to carry rather heavy traffic it was designed for a 10 in. two-course pavement, with a 7 in. base and a 3 in. topping. The width was to be 42 ft., and separation was made by means of separation plates and by means of Blaw-Knox road forms. The methods were much the same as on the Laramie Ave. job, except here the grading was finished by means of an Austin blade grader pulled by a Holt 5-ton Caterpillar tractor, and rolled by a 10-ton Buffalo steam roller. A Koehring 27-E paver was used, while dry batches were hauled to the job from a material yard about two miles distant in 2-batch dump trucks. The subgrade was sprinkled just ahead of the concrete to minimize drying out of the slab, tar paper was used to afford separation from the curb and gutter, and a solid roller was used instead of a perforated roller.

This work was being done for the Board of Local Improvements by the Central Paving Company, represented by Al. Peterson, general foreman. The Board was represented by P. J. O'Conner, inspector.

Oak Park Avenue.—The final job of the series being done for the City of Chicago by the Board of Local Improvements, observed that day, was the paving of Oak Park Avenue north of North Avenue. This was an asphalt job, on a concrete base, and binder was being laid when the job was visited. This work, being done by the Contracting & Material Co., represented by Antone Mercurio, superintendent, proved of interest. Here the 2-in. of binder was to be followed by a 1½ in. sheet asphalt top. The binder was delivered to the street in 12 Garford trucks and 1 Sterling, the loads averaging 14,400 lb. A gang of 25 men spread the material, and after it had been in place for a short time it was rolled by two 10-ton Erie and 1 10-ton Chicago rollers. Topping was applied the following day in order to insure better work and a better bond. When paving this 28 ft. roadway, this organization found that it coul lay at least 1,500 lin. ft. per nine hour day, or about 80 loads of top and binder. Mr. Mercurio stated that his company now operates a 600 ton plant, and has no trouble handling a good volume of work. He said that the asphalt used on this job provided for a

Fig. 5.—Another View on Laramie Ave. Showing Finishing Work and Wet Burlap for Curing

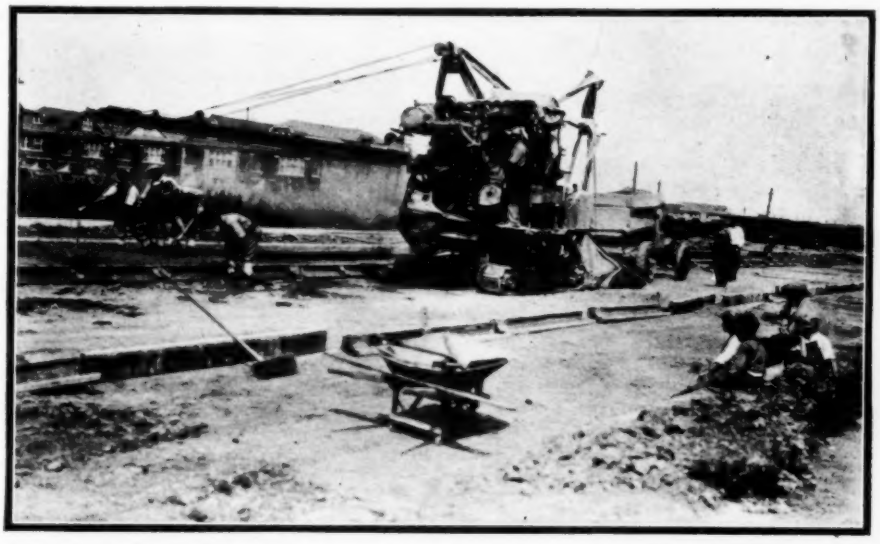


Fig. 6.—Mixing and Placing Concrete on Diversey. Note Strips Separated by Forms, Mixer in Center Strip Paving Right Side

Fig. 7.—The Finishing Operations on the Diversey Job

heavy traffic. He is a firm believer in not rolling too close to the spreading operation, and insists on not putting a topping on a binder that is still hot. On base work, his method is to keep the tampers and broom men well back from the boom of the paver, and to then rebroom the surface so as to give a rougher surface for the binder to key to.

Fig. 8.—Spreading the Binder on Oak Park Ave.

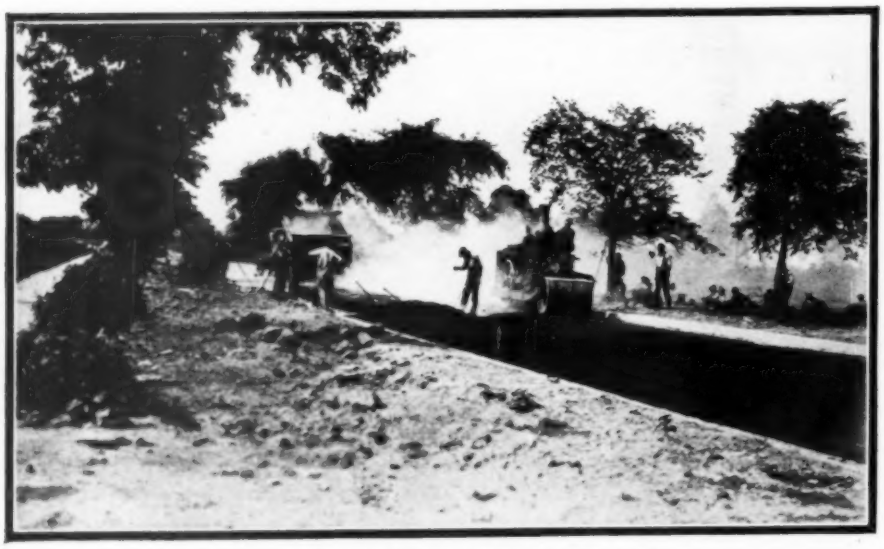


Fig. 9.—Rolling the Binder on the Same Pavement

Fig. 10.—Batch Going Into the Mixer on Oak Park Village Job While Another Is Being Spread

An Oak Park Job.—The Village of Oak Park is a prominent suburb just west of Chicago, and its paving methods are somewhat the same. Here a street just off of North Avenue was seen, where concrete was being laid for an asphalt pavement. This was one of a group of streets being paved in a new subdivision bounded by Ridgland, Oak Park, Euclid, and Edmer Aves., and all concrete was being laid before starting on the asphalt work. Here the work was being done by the contracting firm of W. A. Black & Co., represented by J. J. Martin, superintendent. The village was represented by Martin Thompson, inspector.

This eight inch 1:3:5 concrete base was being laid by a Koehring 27-E paver, with the batches coming dry in a fleet of 18 two-batch trucks of various makes from a material yard 3 miles distant, owned by the Central Lime & Cement Co. The gang included 4 shovel men, 2 broom men, 5 laborers ahead of the paver, and the mixer operator. A wet mix was used. In paving this 28 ft. street, a progress of 1,600 to 1,700 yd. a day was made.

The grading work on this subdivision job was done with two 1-yard Koehring gas shovels and a ½ yard General shovel, followed by a ten-ton roller and an Austin Pup. The asphalt work was done later under separate contract.

An Interesting Job.—A number of interesting new features were found on the paving of that portion of the River Road that runs through the Village of Maywood, a growing suburb west of the Des Plaines River, and some miles west of Oak Park. This portion of this road, which is both a state and county highway, is known as Fifth Ave., and is the original and main business street of the community. On it runs a single track line of the Chicago and West Towns Railways, operators of the suburban street car system. The road, as well as itself being a main north and south highway, acts as a connecting link with several of the main highways leading from the city, and must therefore carry a considerable through traffic as well as a local traffic of some magnitude.

Originally of brick on a topsoil subgrade, and flanked with stone slab curbs, this street is now being paved with reinforced concrete to a greater width than originally provided, all underground work had to be torn up and relaid according to modern requirements, the street lighting system had to be moved back to the new line and replaced, and the old worn out tracks had to be replaced with a new heavy rail section designed for use with the modern pavement. The new track work is designed with the new rail sections placed on wood ties, and resting on crushed limestone ballast. Rails are electrically welded.

Design.—This street is being paved in

accordance with a new design perfected by the engineering firm serving the village. A modification of the Bates Section, this pavement is 9 in. thick except at the shoulders and over the tracks. At the shoulders the thickness is 12 in., tapering to 9 in. at a distance of 3 ft. The slab butts up to the outer side of the nearest rail and is as thick as the height of the rail to the ends of the ties, where the slab is 12 in. thick for a width of 1 ft. The slab then thins out to 9 in. in a distance of 3 ft., with a thickness of 9 in. between this point and the point where the slab begins to thicken to 12 in. 3 ft. from the curb. Between the tracks, which are on the centerline, the thickness is the thickness of the rails. (See Fig. 16).

The main reinforcing is a spot-welded mesh of bars spaced 6 in. on centers, weighing 91.2 lb. per 100 sq. ft. A ⅞ in. shear bar is placed along the edge, while the slab is dowelled to the combined curb and gutter with ¾ in. deformed bars spaced 24 in. on centers. At expansion joints, which are filled with Carey Elastite, ¾ in. slip dowels with tin slip caps on the ends, and oiled, provide continuity of the slabs without interfering with expansion. The design calls for the mesh being carried up to within 2 in. of the rails on each side. Shear bars provide reinforcement between the rails. The tin caps on the slip dowels are made just enough larger than the bars so as to provide an easy sliding fit, and have a lug punched inward at about the mid point to provide for proper placing on the bar during construction. After the pavement is laid and the dowels begin to function, the first expansion shears this lug and the dowels are free to move at will.

While some might suppose that carrying the concrete up to and against the rail might make track maintenance difficult, the engineers are of the opinion that the concrete will prove no more expensive to break out than would well grouted granite block.

Grading.—After removal of old service lines by the corporations and village departments, grading was done with the aid of an Erie ¾ yd. steam shovel, loading into Mack trucks. The old brick were hauled to the village yards but a few blocks away and are to be re-used elsewhere, while other material of no value was taken to the village dumps. This organization could move 200 to 300 yd. of material a day when working with brick, and about 500 yd. a day on dirt. The low performance was mostly due to the fact that the great mass of underground work and existing structures interfered with the grading operation to a great extent.

The Paver.—Dry batches, six bad batches, were delivered in a fleet of 17 two-batch trucks from a material yard in the next suburban town to the west, some 20 blocks away, and dumped into the charging skip of the mixer. The paver used was a Koehring 27-E paver. The batches were proportioned 1:2:3½,

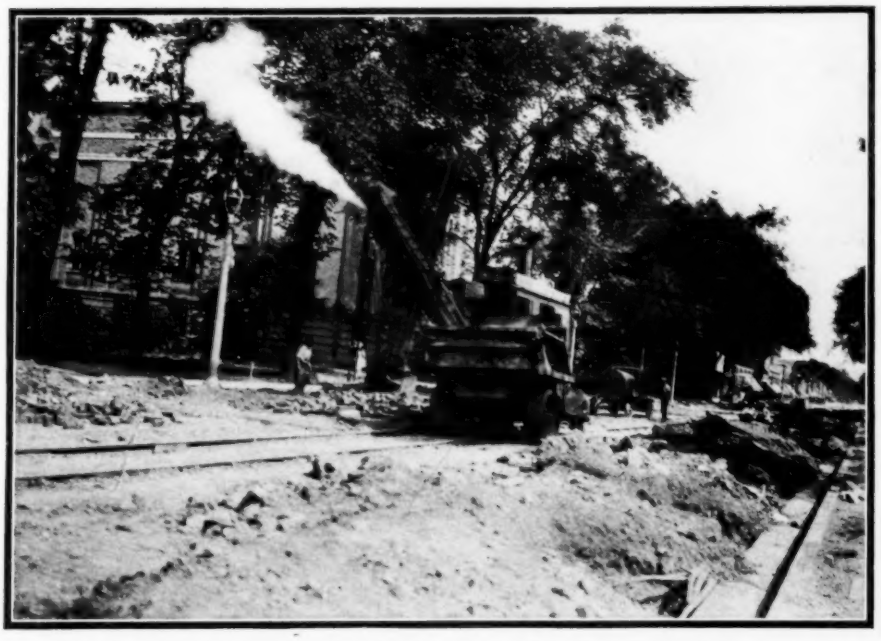


Fig. 11.—Removing the Old Brick Pavement on the Maywood Job

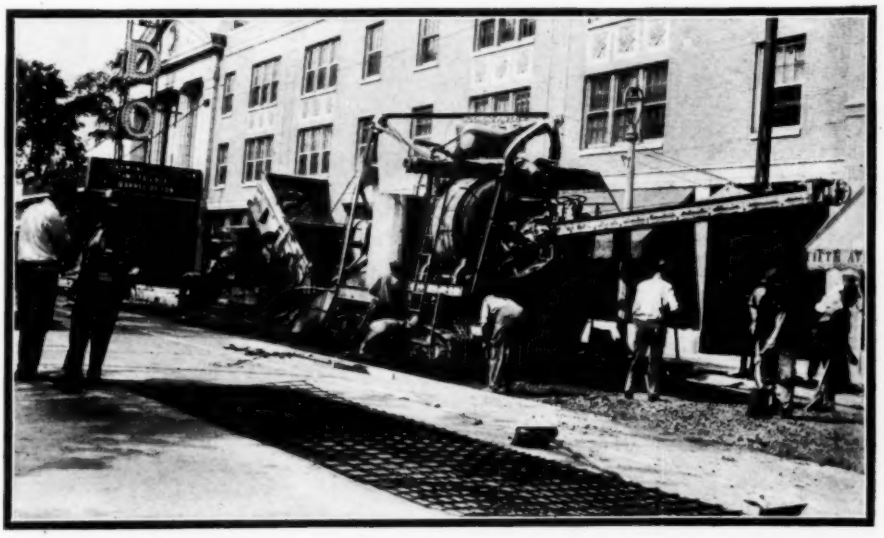


Fig. 12.—A Dry Batch Going Into the Paver on Fifth Ave. While a Mixed Batch Is Being Spread

Fig. 13.—General View of the Finishing Operations on the Same Work

using crushed limestone from a nearby quarry, and mixed as dry as possible, using an average water-cement ratio of 5½ gal. of water to the sack of cement. This gave a mix that showed practically no slump as it came from the bucket, and the shovel men had to use the utmost care to properly embed the steel. The procedure was to first place enough concrete on the subgrade to bring the mesh to the proper elevation, covering an area sufficient to take one sheet of the mesh, and then to lay the mesh on this surface, and then place the rest of the concrete to bring the slab to the desired rough thickness.

Finishing.—A perforated roller was first drawn over the concrete until the surface was properly worked, the slab properly densified, and excess water drawn from the material. Next came a careful floating with a transverse float, then further floating with a longitudinal float, and then after two courses of belting the slab was adjudged finished. The longitudinal float, worked from a square wheeled frame, was used for the purpose of removing waves that would ordinarily make the street bumpy to ride on and lead to impact loads that would impose severe stresses on the slab. Two men on the mixer, 5 shovel men, and 6 finishers, together with the necessary laborers to dress up the subgrade, handle steel, and place the expansion joints, took care of this part of the work.

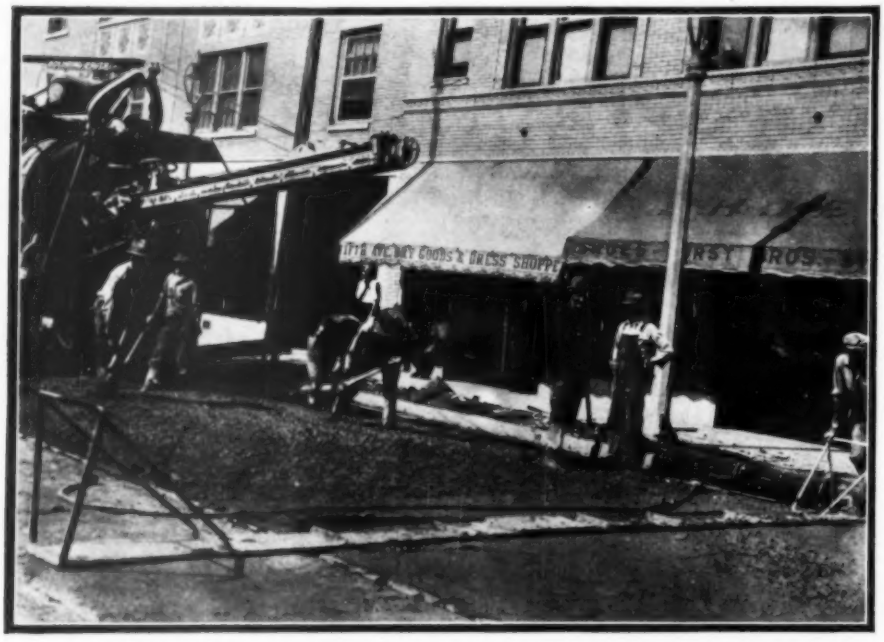


Fig 14.—The Spreading Operation, with the Roller, and the Transverse Float That Are Used

Fig. 15.—The Longitudinal Float and Its Working Frame That Keeps the Men off the Slab

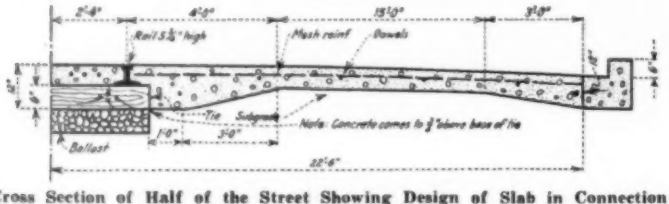


Fig. 16.—Cross Section of Half of the Street Showing Design of Slab in Connection with Car Tracks. A Modification of This Design, Perfected by Mr. Older, Was Used on Another Street Carrying a Double Track Line

Checking the Finish.—An unusual little machine was used on this job to check up on the finished slab for bumps and depressions; used after the slab had secured a good set. This device, invented by District Engineer Lamb of the Illinois State Highway Commission, consists of a main frame with a swivel wheel at each end, plow handles at one end for pushing, and a third vertically moving wheel at the center connecting with a make and break device that shunts an electric current to one of two small bells located on the plow handles. Two 1½ volt dry cells furnish the necessary current, and are mounted on the main frame. When using this device, it is pushed along and across the slab by the inspector. When a depression is encountered, the center wheel lowers into the low spot and makes contact with the lower of the two circuits, ringing one bell. When a bump is found, the wheel raises and closes the other circuit, ringing the other bell. Bells of different tuning make it easy to tell whether it is a bump or depression that has been found. With this device, the inspector can determine the nature of the work much more accurately and with greater speed than with the ordinary straight edge, since the device may be set to register only those departures from the specified limits, and ignore the irregularities that are within the allowed limits. The device is of such a nature that it may be readily improvised on the job.

Other Operations.—For a part of the distance covered by this mile long job the street contains no car tracks. Here the slab was 9 in. thick except for the edges thickened, as already described; 12 in. at the gutter and tapering to 9 in. in 3 ft. Two railroad crossings, one a steam line and one a third-rail electric line, were paved with a hot-mix bituminous macadam.

Those Responsible.—The street was with the cooperation of the Village of Maywood, the State Highway Department, and the County Highway Department, with the state and county paying for 20 ft. and the village paying the remainder by special assessment. The surface lines were not required to do more than lay their own track in a

manner satisfactory to the engineers. The work of grading was done by the Murphy Bros. Teaming Co. of Oak Park, while the paving was done under contract by Jaickes Bros., who were represented on the job by A. F. Klingebiel, foreman. A. V. Baber, acting for the engineering firm of Consoer, Older & Quinlan, was engineer in charge. C. A. Case, who gave this information, is construction engineer for this firm. His firm has been retained as village engineers. J. I. Leach was inspector. State and county were represented on the work by Barney Klinger, county inspector. With these organizations cooperating on the work the paving was progressing at a satisfactory rate when visited, in spite of special difficulties that have constantly interfered.

New Books

Management and Methods in Concrete Highway Construction; by J. L. Harrison, Highway Engineer, U. S. Bureau of Public Roads. Publishers: McGraw-Hill Book Co., Inc., 370 Seventh Avenue, New York City. 242 pages, 74 illustrations, cloth. $3.

Here is a book—we might say handbook—that should fill a long-felt need. It is written for the contractor who seeks better management for the sake of lower costs and better workmanship—written by a man who not only has had a wealth of valuable experience in the field, but who had available the great mass of data that has been collected by the U. S. Bureau of Public Roads.

From start to finish, this book is based upon correct data, sound logic, and mature judgment. It acknowledges the fact that the paving contractor is a business man who must base his bids upon the prevailing market, and who must then so manage his work that it will show an attractive profit regardless of the closeness of the bid. Adequate supervision, according to the author, is required that management may secure the utmost economy in all phases of the work. Sufficient supervisory organization must be afforded in order that the superintendent may devote adequate time and thought to planning every detail of the work and to the elimination of profit leaks.

The book deals with the problems of organization, selection and location of plant, handling the materials, rough and fine grading, and every other element that enters in the work, dicussing the relative merits of alternative methods and equipment from the standpoint of economy and efficiency. The book is arranged in the logical sequence of the planning and the execution of the paving operations. It is concisely written, in clear, easily understood language, and should prove highly valuable to the highway contractor and his superintendents.

Fig. 17.—Placing the Expansion Joint and Slip Dowels. Note How Concrete Covers the Ends of the Ties and Goes Up to the Rails

Fig. 18.—This Homemade Instrument Speeded Up Inspection of the Finishing of the Slab

Fig. 19.—General View of Portion of the Street That Contains No Street Car Tracks

Contractors Aggregate Producing Plant

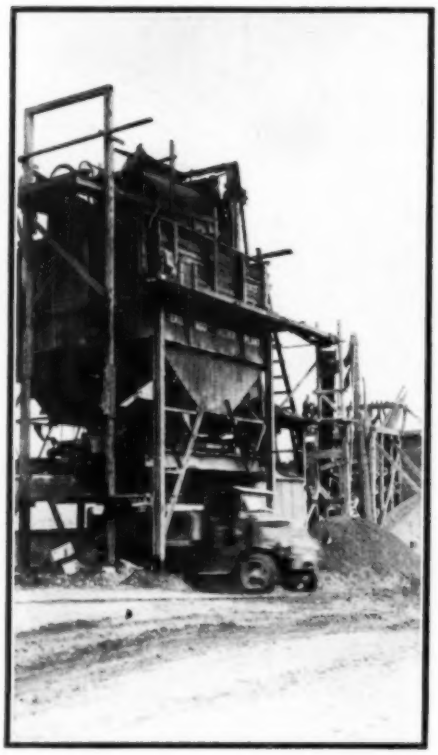
How a New England Contractor Solved Problem of Securing Sand and Gravel for Road Work

Many concrete highways are now being constructed in northern New England to provide more comfortable motoring for the army of vacationists who visit this region annually.

Some of these trunk highways pass through more or less wild country where there are no sand and gravel or crushed stone plants because ordinarily nobody in the locality uses concrete. Consequently, the contractor who bids on one of these highway jobs must figure on producing his own aggregate.

The specifications under which these contracts are let are quite exacting, so the contractor is compelled to install a real washing and screening plant. At the same time, it is very much to the contractor's interest to have a plant that can be knocked down and moved to a new location at a minimum expense. An excellent type of plant for this purpose, installed by Joseph McCormick near South Paris, Me., is shown in the accompanying illustrations.

Mr. McCormick was awarded a contract for building about seven miles of concrete state highway. There was no commercial sand and gravel producer in the vicinity, but a large bank of good sand and gravel located at a convenient point along the road offered Mr. McCormick an easy opportunity to become his own producer.



View of Screening Plant. Receiving Hopper Is at Extreme Right

He obtained a washing and screening plant from the Good Roads Machinery Co. and a 1 cu. yd. Sauerman power drag scraper to do the excavating. The scraper conveys the material up a natural incline onto a grizzly over a receiving hopper, below which is a scalping screen. The tailings from the screen go to a jaw crusher, and the crushed stone together with material which passes through the scalping screen is taken by an elevator to the washing and sizing screen. Four sizes of sand and gravel are separated. The tailings from the screen are returned through a chute to the crusher.

The sand is washed in a drag washer which is located to one side and below the screen, water for washing being obtained from a nearby stream. The different sizes are deposited in small bins above an Erie aggremeter, which turns out a uniform mixture ready to mix with the concrete.

A fleet of 19 Mack trucks is used to transport the aggregate from the plant to the mixer. The body of each truck is divided into four compartments, and when the trucks are run under the aggremeter feeder, which also has four spouts, all compartments are loaded simultaneously.

Scraper Dragging Gravel Up to Hopper

English Experiments With Wood Block Pavements

Some trouble with wood block paving in London, according to the 1925-1926 annual report of the Metropolitan Committee on Means of Paving the Streets of London, has been due to fast and heavy traffic causing movement to the wood blocks, the joints opened and water getting under the paving, causing damage to the foundations in many cases. It was also found that, as a result of the close jointed method of paving generally adopted, particularly if the weather is cold or damp, the grouting material does not penetrate into the joints, or only very slightly, and this is soon sucked out by the traffic, similar difficulties arising from water entering open joints. Considerable displacement of the wood, at times, takes place.

In order to obviate this difficulty and at the same time preserve a water-tight joint, experiments have been made with two kinds of specially-made blocks, produced by different firms; one kind in Aldwych, between the Strand and the east side of Kingsway, and the other in Lower Regent Street from Waterloo place to No. 5. In the former case the blocks are kept apart by a thin strip of wood 1 in. in depth, attached to the bottom of the block for its full length, and two smaller pieces near the top, which effectively prevent the block from moving, at the same time allowing sufficient space for properly grouting the joints. In the latter case, a somewhat similar result is arrived at by cutting down the side and one end of each block so as to leave two slightly projecting lugs on one side and a similar lug at one end.

Tests of Fine Aggregate for Concrete

Use of Lumnite Cement for Short Time Tests to Determine Quality Described in Paper Presented June 22 at 30th Annual Meeting American Society for Testing Materials

By SANFORD E. THOMPSON and MILES N. CLAIR

President, The Thompson & Lichtner Co., Boston, Mass.; Construction Engineer, The Thompson & Lichtner Co.

The large amount of information being made available concerning the various factors affecting the quality of concrete is making engineers realize that many items previously given but slight attention are of vital importance from the standpoint of economy and durability.

This interest in quality control is reflected in the more general use in specifications of the requirement that materials be subjected to complete laboratory examination preliminary to their use on the job. The period between the date of the signing of the contract for construction and the time the materials are required for the first concrete is often a matter of only a few weeks. If the time required to collect the samples of materials to get them to the testing laboratory is considered, it is obvious that time available for the tests is usually a matter of a few days. Most of the present standard tests of materials entering into concrete require from 7 to 28 days before a definite rejection or acceptance can be made. The result is, generally, that either the material is used without awaiting the results of the laboratory examination or the job is held up.

Various organizations have developed certain tests to enable them to identify within a very short time those materials definitely satisfactory or definitely unsatisfactory. The 1-day neat test gives a good indication when information is desired within a short time on a particular lot of cement. Likewise, a 3-day tension test of mortar briquets has been used to supplement the standard 7 and 28-day mortar test for fine aggregates.

A 24-Hour Test.—This paper was prepared to bring to the attention of those who have to do with the testing and selection of fine aggregates for concrete, data from the use in commercial testing practice of a mortar-strength briquet test made at 24 hours using Lumnite cement. There will be given a short statement of the method of making this test, a tabulation of data for comparison of the Lumnite tests with the portland-cement mortar tests at 3, 7 and 28 days, and a brief discussion of these data.

The demand for quick information in regard to the quality of fine aggregate led the organization with which the authors are connected to experiment with and adopt the 3-day portland-cement mortar test, about six years ago, to supplement the usual 7 and 28-day tests. Preliminary experiments showed that three days was about the shortest period that could be used to give consistent results. The tests were made in accordance with the A. S. T. M. standards except that an extra set of the briquets was made up for test at three days. However, three days was too long a period in many cases, and, therefore, rather than base a preliminary rejection or acceptance on the information given by the usual examination and chemical tests alone, experimentation was started on a 24-hour test. The preliminary tests with Lumnite cement showed that it gave results that were reasonably concordant with those obtained by the standard method and so about the middle of 1925 the 3-day portland-cement test was discarded and a 1-day Lumnite-cement test

Table I—Results of Tests on Fine Aggregate, Including Both Lumnite and Portland Cement Tests

Test	Source of Fine Aggregate	Fineness Modulus	Silt, per cent	Organic Matter, parts per million of tannic acid	Strength Ratio			Remarks
					Lumnite Cement	Portland Cement		
					24 Hours	7 Days	28 Days	
No. 1	Eastern Massachusetts	2.95	0.5	none	138	145	140	Bank sand.
No. 2	Western Massachusetts	3.40	0.86	none	137	139	136	Lacking in fines. Bank sand.
No. 3	Eastern Massachusetts	3.07	2.5	20	161	167	158	Bank sand.
No. 4	Western Massachusetts	3.93	2.8	500	158	151	149	Bank sand.
No. 5	Eastern Massachusetts	3.23	1.8	none	146	137	123	Bank sand.
No. 6	Western Massachusetts	3.16	4.0	20	131	124	128	Bank sand. Excess of material passing No. 100 sieve.
No. 7	Eastern Massachusetts	3.87	2.5	100	134	140	127	Bank sand.
No. 8	Eastern Massachusetts	2.45	0.8	20	104	100	102	High in fine material. Bank sand.
No. 9	Eastern Massachusetts	2.25	2.1	100	110	105	100	Bank sand.
No. 10	Eastern Massachusetts	2.26	3.5	20	127	100	100	Bank sand.
No. 11	Eastern Massachusetts	2.72	3.0	20	115	111	115	River sand.
No. 12	Central Massachusetts	3.24	0.3	20	97	99	89	Bank sand.
No. 13	Central Massachusetts	2.18	2.6	250	87	82	83	Bank sand. Excessive fines.
No. 14	Eastern Massachusetts	3.00	2.8	none	135	154	155	Bank sand.
No. 15	Western Massachusetts	2.89	8.0	100	85	81	98	Bank sand.
No. 16	Western Massachusetts	2.25	4.4	20	96	114	117	Excess fines. Bank sand.
No. 17	Western Massachusetts	2.84	4.0	20	135	108	122	Excess fines. Bank sand.
No. 18	Western Massachusetts	3.16	5.0	20	106	111	115	Excess fines. Bank sand.
No. 19	Eastern Massachusetts	2.37	1.2	100	112	105	100	Bank sand.
No. 20	Eastern Massachusetts	....	...	20	114	108	97	Bank sand.
No. 21	Eastern Massachusetts	....	...	20	101	108	97	Bank sand.
No. 22	Eastern Massachusetts	2.44	1.0	none	118	116	120	Bank sand.
No. 23	Eastern Massachusetts	2.62	7.0	250	129	132	129	Excess fines. Bank sand.
No. 24	Eastern Massachusetts	3.23	1.0	20	131	141	119	Irregular. Bank sand.
No. 25	Central Connecticut	2.47	0.5	20	104	97	88	Poor. Bank sand.
No. 26	Central Connecticut	2.57	3.0	250	114	103	101	Bank sand.
No. 27	Maine	1.88	...	none	118	113	116	Passable. Bank sand.
No. 28	Central Maine	2.40	1.5	20	100	114	113	Bank sand.
No. 29	Southeastern Maine	3.84	...	none	132	145	134	Bank sand.
No. 30	Western New York	2.86	4.9	20	124	138	136	Good. Bank sand.
No. 31	Southeastern New York	4.34	...	20	100	110	102	River sand.
No. 32	Western New York	2.72	1.1	100	87	101	103	Bank sand. Irregular.
No. 33	Eastern New York	2.64	2.2	20	81	86	81	Beach sand.
No. 34	Southern New Jersey	2.74	0.3	20	144	120	123	Bank sand.
No. 35	Southern New Jersey	2.52	0.8	100	95	108	102	Bank sand.
No. 36	Southern New Jersey	2.08	1.2	20	98	96	93	Excess fine. River sand.
No. 37	Southern New Jersey	3.04	0.2	none	144	138	116	Lacks fines. River sand.
No. 38	Southern New Jersey	2.45	0.4	250	121	107	102	River sand.
No. 39	Southern New Jersey	2.54	0.1	100	118	120	113	Bank sand.
No. 40	Southern New Jersey	2.60	0.2	100	100	117	114	River sand.
No. 41	Northeastern New Jersey	2.25	3.8	20	113	116	113	River sand.
No. 42	Central New Jersey	1.86	0.9	none	95	95	97	Beach sand.
No. 43	Northern Maryland	2.87	1.0	20	105	112	115	River sand.
No. 44	Central Tennessee	....	...	200	125	89	92	Excess fine. River sand.
No. 45	Central Tennessee	....	...	250	70	83	78	Excess fine. River sand.
No. 46	Central Tennessee	....	...	200	93	121	93	River sand.
No. 47	Central Tennessee	....	...	200	82	115	86	River sand.
No. 48	Tennessee	2.94	1.2	none	110	147	154	Bank sand.
No. 49	Tennessee	3.03	0.7	100	83	103	83	River sand.
No. 50	Tennessee	1.46	6.2	20	53	68	58	River sand.
No. 51	Tennessee	2.68	0.3	20	88	95	91	River sand.
No. 52	Tennessee	2.10	0.8	250	84	86	79	Excess fine. Bank sand.
No. 53	Tennessee	2.74	0.4	200	92	93	82	Irregular. Bank sand.
No. 54	Tennessee	2.88	0.2	20	100	100	98	River sand.
No. 55	Delaware	2.92	1.2	100	138	131	139	Bank sand.
No. 56	West Virginia	2.39	0.4	250	58	81	85	Irregular. River sand.
No. 57	West Virginia	2.37	0.5	250	115	100	106	Poor. River sand.
No. 58	West Virginia	2.60	0.5	250	100	95	99	River sand.
No. 59	South Carolina	2.98	passable	20	96	101	96	Bank sand.
No. 60	South Carolina	2.31	excess	20	74	82	72	Bank sand.
No. 61	South Carolina	2.27	excess	20	60	87	76	Passable. Bank sand.
No. 62	South Carolina	3.04	0.5	20	60	87	76	Bank sand.
No. 63	South Carolina	3.39	0.4	250	121	118	115	Bank sand.
No. 64	South Carolina	2.98	...	80	100	93	83	Bank sand.
No. 65	Louisiana	2.16	1.3	20	100	103	98	High fine. River sand.

Table I (Continued)

No. 66	Eastern Georgia	2.64	0.2	137	37	139	136	River sand.
No. 67	Eastern Georgia	2.97	0.2	80	80	87	80	Poor. River sand.
No. 68	Georgia	2.10	1.0	100	85	91	83	River sand.
No. 69	Georgia	2.00	0.2	100	71	90	80	Bank sand.
No. 70	Azores	1.92	1.5	none	43	72	68	Volcanic origin. Beach sand.
No. 71	Azores	3.72	3.0	none	70	96	83	Volcanic origin. Beach sand.
No. 72	Azores	2.95 †	0.1	none	156	158	130	Volcanic. Lacks fines. Beach sand.
No. 73	Azores	3.27	...	none	94	101	90	Volcanic. Beach sand.
No. 74	Azores	2.82	...	none	67	107	90	Volcanic. Beach sand.
No. 75	Azores	3.12	...	none	74	110	88	Volcanic. Beach sand.
No. 76	Panama	2.80	3.4	100	97	115	100	Limestone. River sand.
No. 77	Panama	3.29	3.2	60	95	105	106	River sand.
No. 78	Central Ohio	3.52	1.4	20	145	156	157	River sand.
No. 79	Central Ohio	4.03	1.1	20	124	156	145	Coarse. River sand.
No. 80	Northern Michigan	3.14	0.7	20	134	146	125	Bank sand.
No. 81	Northwestern Illinois	3.57	0.3	none	160	146	140	Coarse. Bank sand.
No. 82	Central Illinois	2.75	0.5	100	100	100	103	Bank sand.
No. 83	Illinois	1.60	0.8	none	48	37	51	Very fine. Carbon coated. Special.
No. 84	Arkansas	2.01	0.6	250	89	75	90	Poor. River sand

Table II—Results of Tests on Fine Aggregates, Including Portland Cement Tests

Test	Source of Fine Aggregate	Fineness Modulus	Silt, per cent	Organic Matter, parts per million of tannic acid	Strength Ratio, Portland Cement			Remarks
					3 Days	7 Days	28 Days	
No. 1	Massachusetts	....	...	...	121	114	108	Bank sand.
No. 2	Northeastern Massachusetts	....	...	none	101	103	102	Bank sand.
No. 3	Northeastern Massachusetts	....	...	none	102	102	101	Bank sand.
No. 4	Northeastern Massachusetts	3.58	...	none	155	121	141	Bank sand.
No. 5	Northeastern Massachusetts	2.86	...	none	124	112	102	Bank sand.
No. 6	Northeastern Massachusetts	3.06	...	none	114	102	102	Bank sand.
No. 7	Central Massachusetts	....	...	100	100	104	87	Bank sand.
No. 8	Massachusetts	....	...	500	6	4	46	Band sand.
No. 9	Massachusetts	....	...	none	100	100	95	Bank sand.
No. 10	Eastern Massachusetts	....	...	none	100	109	86	Bank sand.
No. 11	Massachusetts	....	...	none	98	102	111	Bank sand.
No. 12	Northeastern Massachusetts	....	...	none	95	100	101	Bank sand.
No. 13	Northeastern Massachusetts	....	...	none	100	161	100	Bank sand.
No. 14	Northeastern Massachusetts	....	...	none	96	101	101	Bank sand.
No. 15	Northeastern Massachusetts	....	...	none	101	102	103	Bank sand.
No. 16	Massachusetts	....	...	none	101	116	125	Bank sand.
No. 17	Massachusetts	....	...	none	117	125	110	River sand.
No. 18	Massachusetts	....	...	none	96	101	101	Bank sand.
No. 19	Massachusetts	....	...	none	105	120	107	Bank sand.
No. 20	Massachusetts	2.06	...	none	57	71	80	Bank sand.
No. 21	Massachusetts	....	...	none	119	190	100	Bank sand.
No. 22	Massachusetts	....	...	none	123	109	101	Bank sand.
No. 23	Massachusetts	....	...	20	104	103	107	Bank sand.
No. 24	Massachusetts	....	...	none	101	116	125	Bank sand.
No. 25	Massachusetts	....	...	none	101	100	102	Bank sand.
No. 26	Massachusetts	3.85	...	none	102	107	103	Bank sand.
No. 27	Massachusetts	....	...	none	113	100	101	Bank sand.
No. 28	Massachusetts	....	...	none	102	105	105	Bank sand.
No. 29	Massachusetts	....	...	350	145	143	118	Bank sand.
No. 30	Massachusetts	2.39	3.1	300	96	86	82	Bank sand.
No. 31	Massachusetts	3.13	...	none	132	129	121	River sand.
No. 32	Massachusetts	3.43	0.5	20	123	138	118	Bank sand.
No. 33	Massachusetts	2.36	..	250	125	116	93	Bank sand.
No. 34	Massachusetts	3.57	...	350	146	146	127	Bank sand.
No. 35	Massachusetts	2.50	...	none	100	100	103	Bank sand.
No. 36	Massachusetts	3.10	...	none	113	115	106	Bank sand.
No. 37	Massachusetts	2.55	...	none	101	100	100	Bank sand.
No. 38	Massachusetts	2.66	...	none	92	94	100	Bank sand.
No. 39	Massachusetts	2.67	...	none	123	112	112	Irregular. Bank sand.
No. 40	Massachusetts	3.14	...	none	114	112	112	Irregular. Bank sand.
No. 41	Massachusetts	3.10	...	500	33	86	57	Coarse. Bank sand.
No. 42	Massachusetts	2.67	...	none	100	102	102	Bank sand.
No. 43	Massachusetts	2.55	...	none	99	100	108	Bank sand.
No. 44	Massachusetts	2.73	...	none	96	125	115	Bank sand.
No. 45	Massachusetts	3.10	excess	none	113	115	106	Bank sand.
No. 46	Massachusetts	2.55	2.0	none	100	113	102	Bank sand.
No. 47	Massachusetts	3.42	5.4	none	129	141	111	Bank sand.
No. 48	Massachusetts	2.44	0.76	none	106	121	121	Bank sand.
No. 49	Massachusetts	3.10	0.64	none	121	142	148	Bank sand.
No. 50	Massachusetts	2.76	...	100	104	131	112	Bank sand.
No. 51	Massachusetts	2.12	...	100	74	81	80	Excess fines. Bank sand.
No. 52	Massachusetts	2.21	2	20	126	122	93	Bank sand.
No. 53	Western Massachusetts	....	...	none	130	136	118	Bank sand.
No. 54	Massachusetts	....	...	none	123	124	140	Bank sand.
No. 55	Western Massachusetts	....	...	none	74	80	85	Bank sand.
No. 56	Massachusetts	....	...	none	92	95	101	Bank sand.
No. 57	Massachusetts	2.75	...	none	112	119	115	Bank sand.
No. 58	Massachusetts	....	...	none	114	20	109	Bank sand.
No. 59	Massachusetts	2.35	...	none	128	128	120	Bank sand.
No. 60	Massachusetts	....	...	350	71	92	90	Bank sand.
No. 61	Massachusetts	....	...	none	136	146	125	Bank sand.
No. 62	Massachusetts	....	...	none	131	127	113	Bank sand.
No. 63	Massachusetts	3.01	...	none	131	107	105	Bank sand.
No. 64	Massachusetts	....	...	none	114	120	103	Bank sand.
No. 65	Massachusetts	2.26	...	none	134	125	104	Bank sand.
No. 66	Maine	3.33	...	none	103	105	104	Bank sand.
No. 67	Maine	2.24	...	none	103	105	104	Bank sand.
No. 68	Maine	....	...	100	82	93	92	Bank sand
No. 69	Maine	....	...	350	73	72	79	Bank sand
No. 70	Southeastern Maine	....	...	none	78	100	100	Bank sand

adopted as standard laboratory practice to supplement the portland-cement tests at 7 and 28 days.

Test Procedure.—The procedure used for this test is in accordance with the requirements of the A. S. T. M. Specifications for Concrete Aggregates (C 33—26 T), except that certain details which are not definitely stated in the specifications have been standardized for our work. A batch using 750 g. of standard sand, 250 g. of cement and a quantity of water based on the normal consistency of the cement, is made up and the consistency of this batch determined by a small flow table. The proper amount of water that will give the same consistency for the job sand as that of the standard sand is then determined by trial. The briquets are made using the quantity of water so determined. The water used for the Lumnite briquets is in the same proportion, but is based on the normal consistency of the Lumnite cement.

This consistency, as mentioned above, is determined by means of a small flow table. This table is similar in construction to the usual flow table used for concrete, except that the plate is only 10 in. in diameter and has a drop of ¼ in. The truncated cone used with it is 2 in. deep and tapers from a diameter of 2¾ in. at the top to 4 in. at the bottom. The procedure in using this apparatus is to fill the mold to one-third of its height with the mortar, then rod 25 times with a ¼-in. diameter rod; repeat for two-thirds full; and finally fill and rod. The top is levelled off by four strokes of the trowel and the cone removed at once. The table is then jigged for 45 seconds at the rate of one drop every 1½ seconds. The average diameter of the base of the cone of mortar is measured with a caliper and this is fixed and used for the job sand.

The portland-cement briquets are stored in the standard manner. The Lumnite-cement specimens are covered with steel or glass plates on both sides and it is important that these be held tightly in place.

The essential requirements for success in the use of this method is the absolute prevention of contamination of the Lumnite cement by portland cement, lime and calcium chloride, and use of the plates on both sides of the specimens. It is preferable that entirely separate tables be used for the two cements. Failure to observe these precautions will result in faulty briquets.

Test Data.—Table I gives data from commercial tests made on fine aggregate for concrete using the Lumnite-cement 24-hour test to supplement the usual 7 and 28-day portland-cement tests. The data are not selected data, but represent all that it is feasible to present at this time. The tests were made by several different operators using seven different brands of portland cement. Certain characteristics of the materials are indicated where available. The strength ratio for the Lumnite cement is based on Lumnite-cement briquets as 100 made at the same time using standard Ottawa sand. The strength ratio for the portland cement is based on portland-cement briquets as

Table II (Continued)

No. 71	Southeastern Maine	....	...	none	95	89	91	Bank sand.
No. 72	Southeastern Maine	....	...	none	92	77	82	Bank sand.
No. 73	Southeastern Maine	....	...	none	120	141	136	Bank sand.
No. 74	Maine	2.45	...	none	82	106	109	Bank sand.
No. 75	Maine	2.52	...	none	83	109	109	Irregular. Bank sand.
No. 76	Maine	2.61	...	20	53	93	91	Irregular. Bank sand.
No. 77	Maine	2.38	...	none	101	126	129	Bank sand.
No. 78	South Carolina	2.03	...	none	102	102	101	Bank sand.
No. 79	Vermont	....	...	100	110	102	101	Bank sand.
No. 80	Vermont	....	...	500	46	31	23	Bank sand.
No. 81	Connecticut	....	...	5	30	56	67	Bank sand.
No. 82	Connecticut	....	...	100	89	96	98	Bank sand.
No. 83	Connecticut	....	...	100	85	96	100	Bank sand.
No. 84	Connecticut	....	...	none	110	119	123	Bank sand.
No. 85	Connecticut	2.31	...	none	100	111	103	Excess fines. Bank sand.
No. 86	New Hampshire	....	...	none	111	105	102	Bank sand.
No. 87	New Hampshire	....	...	350	78	94	85	Bank sand.
No. 88	New Hampshire	2.02	...	none	131	107	105	Bank sand.
No. 89	New Hampshire	1.77	...	none	112	119	115	Bank sand.
No. 90	New York	....	...	none	102	102	101	Bank sand.
No. 91	Eastern Pennsylvania	....	...	none	131	131	152	Slag.
No. 92	Central Pennsylvania	2.81	...	none	108	115	118	Bank sand.
No. 93	Central Pennsylvania	1.66	...	350	62	63	75	Bank sand.
No. 94	Pennsylvania	....	...	none	106	102	103	Bank sand.
No. 95	Pennsylvania	....	...	none	71	65	98	Bank sand.
No. 96	Eastern Pennsylvania	....	...	none	84	84	95	Slag.
No. 97	New Jersey	....	...	none	106	112	110	Bank sand.
No. 98	Maryland	....	...	none	132	129	113	Bank sand.
No. 99	District of Columbia	....	...	none	116	101	99	River sand.
No. 100	District of Columbia	....	...	none	75	68	88	River sand.
No. 101	Tennessee	....	...	20	96	93	98	Bank sand.
No. 102	Tennessee	....	...	20	100	102	105	Bank sand.
No. 103	Tennessee	2.58	...	none	88	91	92	Bank sand.
No. 104	Tennessee	2.93	...	20	87	98	89	Irregular. Bank sand.
No. 105	Tennessee	2.83	...	250	102	102	101	Irregular. Bank sand.
No. 106	Kentucky	3.40	...	none	161	151	148	Bank sand.
No. 107	Kentucky	3.18	...	100	59	73	85	Bank sand.
No. 108	North Carolina	2.99	0.2	20	100	103	107	Bank sand.
No. 109	Florida	....	...	none	100	100	101	Excess fines. River sand.
No. 110	New York	....	...	none	95	101	136	Bank sand.
No. 111	Minnesota	3.27	...	none	145	139	121	Soft stone. Bank sand.
No. 112	Minnesota	....	...	none	104	131	100	Bank sand.

100 made at the same time as the Lumnite briquets and using standard sand. Under the heading "Remarks" is included information as to the brand of sand and its grading. Sand concerning which there are no remarks may in general be considered as being of fairly satisfactory grading.

Table II is given for comparison of the 3-day mortar test with the Lumnite-cement tests given in Table I. It presents data from commercial tests of fine aggregate for concrete made during a period of three to four years prior to the Lumnite tests. There was much less information available in regard to the characteristics of those materials than for those tested during the last two years. The strength ratio for the 3-day portland-cement briquets is based on a corresponding set using standard sand as 100 and made at the same time.

Discussion.—The data in Table I show considerable variation in individual cases between the Lumnite-cement test and the portland-cement 28-day test, which is taken as standard. The average difference, however, is negligible, the Lumnite test tending to be slightly optimistic. The 7-day tests with the portland cement do not agree as closely with the 28-day tests as do the Lumnite tests.

We use a mortar-strength ratio of 85 per cent at 28 days as the lowest acceptable for a concrete aggregate which shows a high organic content. Using this as a basis, it would appear from the table that only four would have been rejected which were usable and two would have been accepted which were not usable. Actually, other factors governed in all of these cases.

Comparing the information of Table II with that of Table I, it is seen that the two methods of test show about the same average variation from the 28-day ratio, but the 3-day test is slightly pessimistic, while the Lumnite test is slightly optimistic.

Conclusion.—The Lumnite-cement 24-hour mortar test for determining the quality of fine aggregate for concrete, made in accordance with the method described in this paper, gives results comparable with those obtained by the portland-cement mortar test at 28 days. We consider it of value where information must be obtained concerning the qualities of fine aggregate within 24 hours and which is to be checked by portland-cement tests later.

The Need for Traffic Engineers for Cities

A city engineer charged with the constant study of local traffic conditions in order to observe changing needs and counsel adequate preparations to meet them should be in the service of every American city of more than 25,000 population and in many smaller cities as well, according to a recent statement by Miller McClintock, director of the Albert Russel Erskine Bureau for Street Traffic Research.

The complexities of modern city traffic brought about by the rapid increase of motor vehicle registrations, changes in city conditions as a result of building operations, the shift of business districts and many other factors require constant study if a city is to keep abreast of its traffic and safety problems, he stated in Chicago before more than 100 mayors and city officials who had met to discuss traffic and safety matters.

"Few problems of administration facing officials of American cities have become as important and complex in the past decade as the effective regulation of street traffic. Provided for the most part with an archaic code of traffic laws as out of date as the horse and buggy, they have been put to the necessity of coping as best they could with the task of traffic control. From time to time the pressure of conditions brought about changes in administrative organization and traffic control, but these changes have seldom been developed on a basis of thorough engineering study of all the problems involved."

One of the major recommendations in the widely quoted Chicago traffic survey made by the Erskine Bureau, which is endowed in Harvard University by the Studebaker Corporation, involved the creation of a traffic engineering division in the department of public works and the appointment of an engineer whose full duty should be the study of street accidents and traffic conditions, the preparation of recommendations for improvement, and supervision of the placing and operation of all city traffic signs and signals.

Adoption of this recommendation by a special act of the city council set a precedent many other large cities are considering in the treatment of their traffic difficulties.

The city traffic engineer serves to supply accurate and up-to-date information to the city traffic commission, also formed on the basis of the traffic survey's report and recommendation, and consisting of representatives of city departments charged with the various duties relating to traffic control.

This recommendation for a city traffic engineer and traffic commission is in harmony with the proposals of the National Conference on Street and Highway Safety formed by Herbert Hoover, Secretary of Commerce. "The traffic commission should have accurate records of traffic movement, observe changing conditions affecting trade, suggest amendments to the traffic ordinance and keep the traffic survey and plan up-to-date," says the Hoover committee's report.

The Chicago survey's recommendation for a traffic engineer and city traffic committee was based on the assumption that satisfactory control of traffic can never come from casual observation or guess-work, but must be based on sound facts gathered along engineering lines. One of the functions of the Erskine Bureau, as outlined by A. R. Erskine, president of the Studebaker Corporation, is to aid American cities in the development of better traffic regulation and safety measures through engineering research in street traffic problems. In carrying out this work Dr. McClintock, as director of the bureau, is serving as traffic consultant and director of traffic surveys in Chicago, Los Angeles, Boston, San Francisco, and a number of other cities faced with acute traffic problems.

Winter Highway Work

Experiences in Various States Summarized in the March Constructor

In spite of the fact that in northern climates there is of necessity a seasonal peak in the carrying on of highway work, twelve states report at least some degree of success in meeting the problem. Although actual construction is practically at a standstill between Dec. 1 and April 1, means have been evolved enabling contractors to get their plants set up during the winter and spring and to store materials.

By following this plan in Illinois, contractors are ready to start work as soon as the construction season opens and are able to prosecute their contracts without inconvenience or delay during the comparatively short period available for working on the roads, according to highway officials. Contracts in this state are awarded during the fall, winter and early spring months for work to be carried out during the following construction season.

Frank T. Sheets, Chief Highway Engineer for Illinois, is enthusiastic in his praise of this arrangement, stating that "it tends to distribute the transportation problem over a longer period of time and to stabilize the construction industry. Generally speaking, our greatest volume of contract letting occurs from November to March. By following this plan we are able to utilize our engineering forces for surveys and the preparation of plans during the fall and winter months and for construction during the construction season. This avoids lay-off of our forces and consequent turnover."

Reducing Seasonal Peak by December Lettings.—Engineers in several states report inability to overcome seasonal peaks because of lack of cooperation by the Legislature in making appropriations. On the other hand, A. W. Dean, Chief Engineer for Massachusetts, says, "This department has been able to reduce to a considerable extent the seasonal peak in the letting of highway contracts by securing authority from the Legislature whereby contracts may be let in December for work that is to be carried on during the following year."

The department is enabled to do this by an act which permits the letting of contracts for reconstruction work on state highways in anticipation of appropriations that are usually made in the latter part of March. The extent of such lettings is limited to 25 per cent of the appropriation for similar purposes made during the current year. Under this act $1,400,000 worth of work was let during December, 1926.

The Massachusetts Highway Division has also been fortunate in that it has not been subject to depressions in the trend of volume of lettings during the summer months.

Roy A. Klein, Oregon State Highway Engineer, points out that "there is a great deal of advantage to the state as well as the contractor in avoiding the peak season and in giving the contractor ample time to prepare for his work in advance of the actual construction season."

Practice in Oregon and Mississippi.—Whenever possible the Oregon Highway Commission endeavors to receive bids in the fall for construction to be carried on during the next working season. Contracts awarded by this Commission have been fairly well distributed over the entire year.

In Mississippi the practice has always been to award contracts as rapidly as finances are provided and plans prepared. No consideration is given to the season of the year at which the contract is awarded, with the result that lettings have been spread over the year with no seasonal peaks, while the climate, of course, removes many of the problems encountered in states to the north.

By keeping a fairly constant organization employed on surveys and plans, the Pennsylvania Department of Highways has been able to avoid seasonal peaks and depressions in the trend of volume of lettings.

Minnesota Highway Commissioners believe best results are secured from awarding contracts as far in advance as is deemed advisable under the circumstances. Between October, 1925, and January, 1926, contracts were let for practically all the work which was to be done during the year of 1926. The volume of early awards for 1927 was considerably less because the Highway Department was awaiting action of the 1927 legislative session.

Rhode Island Awards Contracts in Late Fall.—In Rhode Island the type of work determines in great measure the time of letting the contract. During the past year, awards were made in March, June, August, September and November.

"It is our practice to award contracts in late fall which involve grading that can be carried on to a large extent during the winter months," explains George H. Henderson, Chief Engineer with the Rhode Island Highway Department. "In these contracts usually there are heavy fills, and we specify that these fills must be made in the fall or early winter to insure settlement before the pavement is laid over them the following summer.

"As far as practicable jobs are placed in the other lettings in accordance with the length of the construction and the amount of work involved, in order that contracts will be completed by the end of the fiscal year."

Maine Awards Contracts in September.—Variations in the funds available for financing highway construction in Maine have made impossible any fixed policy in awarding contracts. Whenever it can be arranged, contracts are awarded in September to allow contractors to get their equipment on the ground and do preliminary work, such as heavy grading and delivering of stone, during the fall months, with the idea of completing the work early the following summer.

Paul D. Sargent, Chief Engineer of the Maine Highway Commission, is convinced of the advisability of making early awards, in spite of the fact that his department has not been able to follow this practice to any extent. "If we had plenty of financing," he says, "and it was known over a period of years just what funds would be available each year, there is no doubt but that we could save a good deal of money by carefully planning and executing such portions of the work as can be done to advantage during what might be called the closed season."

A light program of road building for 1927 has reduced the steady flow of lettings that heretofore has been the rule with the Missouri State Highway Department. Ordinarily, however, this department is able to hold lettings at intervals of from one month to six weeks. This plan, in the opinion of Chief Engineer B. H. Piepmeier, has been successful in reducing seasonal peaks in the past, as up to the present time Missouri has had a very heavy road building program.

In Kentucky and North Dakota the practice is followed of awarding contracts during the winter in order that bonds may be ready and the contractors may lay their plans and stock materials before the earliest possible date for commencing construction in the spring.

R. L. Cochran, State Engineer for Nebraska, reports that the Nebraska Department of Public Works "awards contracts pretty much during the whole year, so that work progresses the year around, whenever weather will permit."

Year Round Construction in Some States.—The climate in Oklahoma, Alabama, North Carolina, Georgia, Texas, Louisiana, Florida, South Carolina, part of Utah and other states permits year-round construction. Because of this fact, the State Highway Departments of South Carolina and Florida have found competent contractors plentiful for winter work, as a number of men from farther north have begun bidding on winter jobs in these southern states.

The Florida Highway Department for the past year or more has resorted to the method of receiving bids on sections

of work about every 60 days. In this way a good class of contractors has been secured. "Furthermore," adds J. L. Cresap, State Highway Engineer, "we give contractors a better opportunity to figure on the work. In letting in larger quantities a man might bid on only one job, and failing to get this, would not be able to secure other work for some time."

For those localities of southern Utah where highway work can be continued throughout the year, the State Road Commission has adopted the plan of awarding contracts at such time as will secure the completion of the major portion of the work during the winter months, when traffic is at a minimum. In other cases, the Commission's aim is to award contracts at such times as will permit the completion of projects during one working season, thus reducing the cost to the state.

Turnover Reduced in Louisiana.—Nicholls W. Bowden, Principal Assistant Engineer for Louisiana, points out that the saving in labor turnover through continuous construction justifies work during the months of January, February and March when the rainy season retards progress in his state.

"It has been our experience that the prices we obtain on lettings held in the late fall and early winter are about as favorable as those obtained in the spring or summer," says Mr. Bowden. "At any rate, the difference is not enough to justify reducing the quantity of winter work and increasing the quantity of summer work. The inconvenience, as well as the cost attendant on laying off and re-employing supervisory forces for highway construction work, is considerable, and it is one of the real problems confronting the highway departments of most states. We find it entirely practicable to maintain our field and office forces practically constant throughout the year and to arrange that the volume of our lettings does not materially change from time to time.

"We do not experience much trouble along the line of depressions in the volume of lettings except when our funds run low in advance of our expectation. This, of course, happens, if at all, near the end of the calendar year, but we have found it possible, through the adoption of a budget at the first of each year, to control this feature fairly well."

Climatic conditions make depressions in the trend of contract lettings unavoidable in states, such as Nevada, Vermont and South Dakota, where winter work is impossible. Contracts are let at the beginning of the season in Vermont in order to insure completion of the work before winter.

South Dakota Spreads Its Lettings Over Season.—Although winter construction cannot be performed economically in South Dakota, the State Highway Commission distributes its awards, letting contracts for approximately half the season's work in the early part of March, a quarter of the work about the middle of the summer, and the remainder in the latter part of September or the first of October. This method of handling contracts, according to O. N. Hetle, Highway Engineer, gives sufficient spread to eliminate largely the tendency to overload some contractors with work while others obtain less than they are able to handle.

No fixed policy relative to seasonal peaks in highway construction is followed in Wyoming, Indiana or Wisconsin. In Wyoming the volume of work is comparatively small, and its character is governed to considerable extent by weather conditions which prevail in that latitude.

Contracts for road work in Indiana are awarded during the early fall and winter preceding the construction season, the Highway Commission considering it useless to advertise for bids on road contracts during the construction season when contractors do not have time to be away from their projects. Contracts for bridge, however, are awarded whenever it is possible to complete a sufficient number of plans to insure an attractive letting.

F. M. Balsley, Construction Engineer with the Wisconsin Highway Commission, says, "Ordinarily we advertise our projects as soon as the plans are completed and approved. Due to the fact that the lettings are distributed over the state, we have no particular trouble with congestion. We aim to award contracts for our work as early in the season as possible."

No success has met efforts to remove seasonal peaks in letting contracts for highway construction in Arkansas, New Hampshire, Kansas, Washington, Ohio or Michigan. Uncertainty as to when appropriations will be available seems to be largely responsible for this condition.

The work in New Hampshire is conducted on a cooperative basis between the state and towns, operations being practically wholly dependent upon the amount of money raised by the towns at their annual meetings held in March. Contracts are awarded as soon as possible after these meetings.

The Washington Highway Department has been unable to eliminate the seasonal peaks in letting highway contracts due to the fact that the laws of the state provide for operating on a two-year program basis. Under this arrangement, it is necessary to conceive, start and complete the program within a two-year period. This results in a peak in letting contracts during the first half of the period and a consequent slump during the last half.

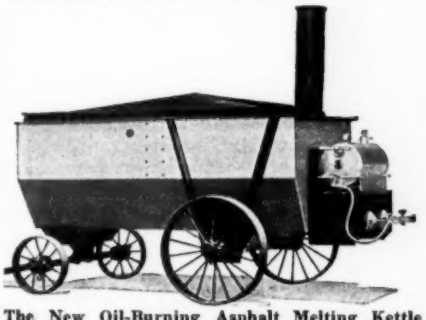
A report from the Ohio Department of Highways and Public Works states that it has been practically impossible to fix dates at which projects will actually be let because the letting is predicated on financing, and this financing may be dependent on federal, state, county or township aid, and on assessment against the property adjoining the improvement.

In Michigan the State Highway Department has been obliged to let highway contracts largely when funds were available. The season for lettings usually extends from April to November, and the work is fairly well distributed over this period.

All road work in Kansas is initiated by the Board of County Commissioners, and is governed somewhat by the amount of federal aid and other funds available for construction. All plan work is handled by county engineers or engineering companies, acting under the County Commissioners. The only check held by the State Highway Commission lies in the fact that the plans must pass through the office of the state department. Because of limitations in appropriations, this task is completed only at a limited speed, with the result that work is spread over practically the entire year.

New Oil Burning Kettle for Road Work

Littleford Bros., of Cincinnati, O., have recently placed on the market an oil-burning asphalt melting kettle for road construction work. It is known as Type No. 83, and is made in two capacities, 300 and 500 gal.



The New Oil-Burning Asphalt Melting Kettle Introduced by Littleford

The new kettle embodies practically all of the features of the Littleford "Contractor's Special" wood-burning kettle. Type No. 48, which Littleford Bros. have been manufacturing for years, except that it is built for burning kerosene or a light furnace oil exclusively.

Two oil burners, of Littleford manufacture, supply an intense heat, which the manufacturer claims will melt batches of asphalt in a much shorter time than is possible with a wood or coal fire.

The kettle carries a fuel tank of 20 gal. capacity, and is mounted on roller bearing wheels and high carbon steel axles. While standard equipment includes all-steel wheels, the kettle is mounted on solid rubber tires with steel heat guards, when desired.

A warming hood to take the place of the standard cover, and a barrel hoist for raising barreled materials, are accessories which can be furnished.

One Cause For Present Low Bidding

Why Contractors Are Submitting Low Bids for Road Work Told in Paper at Meeting of Illinois Association of Highway and Municipal Contractors

By A. E. HORST
Secretary-Treasurer Henry W. Horst Co., Contractors, Rock Island, Ill.

In the "Valve World" (a Crane publication) some months ago Business was described as follows:

"Business is the term applied to the efforts of human beings throughout the world to exchange with one another the various fruits of their labor. It is essential to make this exchange in order that we may supply ourselves with food and clothing and shelter, that is, that we may continue to live. The immediate purpose of business is to supply our needs. The secondary purpose of business is that we may increase our wealth in order that we may enjoy the fruits of our labor through the development of culture and of our spiritual natures."

Business, then should give us wealth; and wealth, properly and wisely used, makes it easier for us to pursue our quest for happiness, which is the goal for all our planning and striving.

Many Contractors in the Field.—Today our particular business happens to be that of constructing permanent highways. From this business then, we that are actively engaged in it, should expect to derive the benefits above described. It is almost the universal custom where highway contracts are to be let, that this work must be secured in the open market on competitive bidding. Because of the large program of road construction that has been started within the past comparatively few years many firms have entered this field as possible contractors. Many of them have had very little, if any, experience in any sort of construction.

Permanent construction of highways, a few years ago, was a new line of endeavor, and it was necessary that a great deal of experimental work be done before definite, intelligent and economical construction of roads was developed. Equipment manufacturers were endeavoring to build such equipment as would help construct these roads for the least cost. It was necessary, however, for the contractor also to experiment largely with his own money to assist in perfecting this comparatively untried equipment.

The Development of Equipment.—Most of you will remember in the early years of highway work two-bag batch mixers were the standard. These mixers have now developed so that as a rule the six-bag batches seem to be the most economical. Many of you will remember the types and various kinds of untried equipment that were on exhibition at the Road Show some six or eight years ago, which at that time we all thought would be the solution of the machinery that should be used in the construction of roads. Compare the equipment for road building that was shown at the road show eight years ago with what is being exhibited there now. All of this to show that road construction during the past ten years was largely an experimental process, and the contractor had to keep very accurate records as to the performance or non-performance of this equipment. Contractors have put much of their money into this experimental stage of road construction.

In the speaker's judgment, in order to determine the reason for present low bidding among contractors, it is necessary for the purpose of discussion, that the field of contractors be divided into two classes. For this purpose, then, we will call Class 1 contractors those who have had at least two to three years' experience in highway contracting, and Class 2 contractors those who had less experience in the road game.

Lack of Cost Records.—The greatest cause for present low bidding among Class 1 contractors (those with more than two years' experience) is, in the speaker's judgment, that these contractors do not keep intelligent cost records of their performances and constantly reflect these cost records in their bids. I like to assume that a contractor has enough brains not to want to lose money on any work that he undertakes to do. I, however, sometimes feel that the contractor is a good deal like a very sick patient for whom the doctor has prescribed medicine that happens to have a very bad taste. The patient proceeds, against his own better judgment, to refuse to take the medicine that has been prescribed and trusts to luck that he may get well without it. This is somewhat similar to the fact that, though a contractor's cost records show he should bid $2.64 per sq. yd. for slab, without cement, he cuts his bid 10, 20 or even 30 per cent and trusts to luck that somehow or other he may come out "right side up." He may also imagine that he must have a job in order to pay his overhead. It is much easier to pay a comparatively small amount of overhead than to secure a contract and pay a much greater amount of money in loss on that contract.

This type of contractor is not willing to add a proper contingency for bad weather conditions. Those contractors who happened to have contracts in this state during the past year and who will analyze their costs intelligently, I believe will find that the weather has had a great deal to do with the delays and exceptionally high unit costs that have obtained in their work this year, and certainly should take these costs into consideration when building up bids on work of this nature in this state in the future.

Advantages of Accurate Cost Records.—The reason for low bidding among Class 2 contractors (those with less than two years' experience, and there seem to be many more of these than of Class 1) is that they do not recognize the value of the equipment that must be charged off in doing a given amount of road work. Such equipments as shovels, mixers, rollers, trucks, subgraders, finishing machines, forms, burlap, tractors, pumps, pipe line, etc.

An experience in our own organization is given. We became interested in the road game in 1919. We had back of us 26 years of experience in building construction and felt that we knew something about construction costs, and thought we also knew something about what the proper depreciation on construction equipment was. Before the first contracts were finished we owned 56 trucks and expected that these trucks would have a normal life of three years, and depreciated them in accordance with this plan. After two years of operation we discovered to our amazement that we were spending so much on these trucks in upkeep, repairs, etc., that it was necesary to dispose of the trucks forthwith. Had we not kept close cost records we would have suffered even more severely.

Our experience in the first year and a half on road construction, even with 26 years of building construction behind us was an exceedingly costly experience, and I am satisfied that had we not kept accurate and intelligent cost records and used these in building up our bids in securing new work, instead of trying to bid without these cost records, we might not have been here today as road contractors with all debts paid. And these records for a year and a half on 13 miles of work did not cost us over $6,000. Accurate and intelligent cost records will always be worth the price if you will only use them after they are once secured.

Some unethical bonding company agents also help to interest would-be contractors in securing a job at any price in order that they may secure the benefit of the bond premium that might be theirs if the contract is awarded.

A contractor should always remember that he is entitled to a fair margin of profit for his work after all other expenses have been paid, and that it is a great deal better for him to lose a job than it is to get a job and lose money on that job.

All Items of Cost Not Considered.—Among contractors of less than two years' experience are very often superintendents or foremen of reliable organizations who branch off in business for themselves without knowing the

complete business of the organization that they have worked for. In other words, a superintendent working for a firm does not secure the entire picture of the job he happens to be running. He may figure that the cost of laying slab for a particular day is reflected in the labor cost on that day, plus the material entering into the operation for that one day, adding a small amount for plant and general expense, and knowing what the bid price is, the difference, in his judgment, is an enormous profit. He does not take into account the loss that deevlops on the job during rainy days, the cost of set-up, the shrinkage in materials in the mixed concrete, the wastage of materials, the overruns to be absorbed, the cost of carrying overhead during seasons when no progress is made, investment in plant, and credit involved to carry on the project, obsolescence of equipment, cost in figuring new work, and many other items of expense that an experienced contractor himself hardly realizes until the end of the year is at hand and the books close in the "red."

The Standard Questionnaires.—One of the things that is going to help in a large measure to prevent acceptance of ridiculously low bids is the continued effort to broadcast and secure the use of the standard questionnaires on which our friend, S. M. Williams of the Autocar Sales & Service Co., has spent much of his time and effort—all as a matter of personal service to the contractor.

For your information, the questionnaires have now been approved by the American Association of State Highway Officials, and adopted by at least 60 per cent of the state highway departments; by the National Surety Association, and adopted by a number of the large companies; by the National Association of Credit Men, for use of their home and affiliated organizations throughout the country; by the American Bankers' Association, through their clearing house section, and 3,500 copies are being distributed to the banks throughout the country, with letters from the president of the clearing house section calling attention to the importance of the forms, and urging their use by the banks in the determining of credit for the contractor.

I am of the opinion that if the contractors, regardless of their experience, would make a real effort to get accurate and intelligent costs of doing business in the highway game and intelligently bid the costs as reflected in actual performances plus a fair margin of profit and contingency, the chief causes for low bidding would be removed.

$30,000,000 of Road Bonds for New Jersey.—The Governor of New Jersey has signed the bill providing for a $30,000,000 bond issue as part of the new state highway financing program.

Keeping Roads Open for Winter Traffic

General Resume of the Snow Removal Situation Given in Radio Address

By PROF. S. S. STERNBERG
Assistant Director, Highway Research Board, National Research Council

One of the recent developments in the service rendered by state highway departments in the snow area is keeping their roads open for traffic throughout the winter months. The funds invested in our highway systems are so large, and the commercial, educational and social activities that are dependent upon highway transportation are so great, as to require that there be rendered to the people of each state uninterrupted highway service very day in the year.

Thirty-Six States Remove Snow From Rural Roads.—Confined until recently to a few states and to a few main routes, snow removal has now become general practice. A recent comprehensive survey made by the United States Bureau of Public Roads has shown that 36 states find it necessary to remove snow from their rural highways and that last winter they kept 93,000 miles of road clear of snow. This was an increase of 50 per cent in mileage over the preceding winter. During the past season, it was planned to keep open an even greater mileage in order to prevent the inconvenience and economic loss occasioned by blockaded roads.

In order properly to plan a snow-removal program, it is necessary for the highway engineer to make a careful study of snowfall statistics available for his area, as well as other climatic factors which affect snow removal, such as temperature, velocity and direction of the wind, and the distribution, frequency and intensity of storms. The records of the United States Weather Bureau are of great value to the engineer in studying snow conditions.

Snowfall Records.—It is interesting to learn from these records that no state in the Union is entirely free of snow. More or less snow falls in all portions of the country with the exception of southern Florida, the lower elevations in southwestern Arizona and southern California. The heaviest snowfall in the United States occurs on the west side of the Sierra Nevada and Cascade Ranges in the states of Washington, Oregon and California, the average annual snowfall in this section being 300 in. or 25 ft. At one place in California, records over a period of years show an average annual snowfall of more than 65 ft. East of the Rocky Mountains, the regions of heaviest snowfall are the Upper Peninsula of Michigan and the Adirondack Mountains in New York, with an average annual snowfall ranging from 10 to 13 ft. In the central section of the Appalachian Mountains, including western Maryland and portions of West Virginia, 7 to 9 ft. of snow fall annually on the average.

Drifts Cause of Trouble.—If snow would lie as it falls, little effort would generally be necessary to remove it from the traveled way and keep highways open the year round for the ever-increasing traffic. In non-mountainous regions, with snow falling rarely to a depth greater than 9 in. for an individual storm, were it to spread uniformly on field and road and remain in that condition, the only equipment necessary for its removal would be the ordinary road grader used in maintenance work, or the simply constructed and inexpensive straight blade plow used with high speed trucks. But, unfortunately, snowfall is usually accompanied by high winds which blow the light snow crystals about, and where they encounter obstacles along the edge of the highway to break the wind current, the snow particles are deposited and cause rifts to form on the traveled way.

Hedges near the roadway, tight or partially tight fences, standing weeds and other vegetation, and in some cases, plank guard rails often produce drifting on the roadway. Where these obstacles are met at a great distance from the road, they form beneficial wind barriers by collecting the loose snow and protecting the traveled way from drifts. Among these are field division fences sufficiently far from the roadway and generally parallel to it, tree stumps, shrubs, bushes, standing timber and even corn stalks left uncut during the winter months. Through forest, or shrub or brush country, snow drifting does not occur as the trees and brush break the wind sweep before it reaches the roadbed.

In northern Michigan, the state is acquiring the rights-of-way 400 ft. wide through wooded land. The trees and brush will be left standing when the roads are improved to serve as drift preventatives, as well as add scenic beauty to the highway.

Methods of Preventing Drifts.—To avoid drifting, a study of the road where snow piles up is necessarily followed by the removal of all weeds and other vegetation from the confines of the right-of-way. Tight board fences must be removed and replaced with wire fence where fences are necessary, and cable guard rail installed where the plank type is troublesome. As a preventive measure against snow drifting, a number of highway departments in planning new road locations are avoiding to a large extent shallow cuts in the roadway and where possible elevating the road grade above the surrounding country.

Where the natural features of the road location are such as to make drifting impossible, the state highway departments are erecting permanent or temporary artificial structures, such as snow fences, at a sufficient distance

from the roadway to cause the blowing snow to be deposited between the fence and the road. This method of drift prevention is found to be very effective and is widely used. Snow fences are placed 50 to 150 ft. away from the road depending upon the topography of the adjacent land. The fence is erected parallel to the road or obliquely but perpendicular to the wind sweep. Generally one line of fence is sufficient but in some cases two are installed. Last winter more than 1,300 miles of snow fence were used by the states located in the snow belt.

In some cases hedges are planted or rows of evergreens are set to the windward side of the road to act as artificial wind barriers with beneficial results. In one county in Michigan, snow blocks are used for the same purpose. It is found that one man can cut the blocks and build one-quarter mile of this fence a day at a cost of from 3 to 5 ct. a running foot. As the snow accumulates on the lee side, more blocks are cut and the fence is raised.

Michigan has recently established an experimental station for the sole purpose of finding out all that can be discovered about snow as it may affect the use of the highway. The results of this study will be of great value to all the other states faced with this important problem.

Snow Removal Methods and Equipment.—The methods followed and equipment used in the removal of snow are many and varied. They range from a strong-armed squad with a trusty shovel to the use of the powerfully built rotary plow, which, when operated in connection with a caterpillar tractor, finds no drift too deep for removal. The most common types of snow removal equipment in use are the straight blade and the V-shaped plow, each attached to the front of a truck or tractor, the type employed depending upon the amount of snow to be moved. This equipment is used either singly or in tandem formation. During the present season the state highway departments have available for use in snow removal more than 3,500 snowplows and 5,000 tractors and trucks.

In some states it is customary to start snow removal operations as soon as the snow has reached a depth of 2 in. and to carry on for the duration of the storm. In other states, this method of attack is impossible as snowfall is too heavy and would blockade the roads soon after clearing and strand the equipment. In such states snow removal is undertaken after the storm has passed.

The cost of snow removal work on the 93,000 miles of road in the United States cleared last winter by the state highway departments was $3,750,000. This is an average cost of $40 per mile, which is a very small outlay when we consider the many advantages that result from open roads in the winter. A blockaded road causes not only a loss on the highway investment, but is a serious handicap to business and social life. It is necessary that the roads be kept open for wheeled traffic at all times, so that rural mail, school and pasenger busses, commercial deliveries, physicians and fire engine may have uninterrupted use of the highway. With snow removal, dwellings are no longer snowed in for the winter, nor do motor vehicles need to be stored for several months of the year.

Snow Removal Saves Maintenance.—The expense of snow removal is considered well justified by the saving in spring road maintenance. Studies made in some states demonstrate that the additional gas tax received from motor cars and trucks used during the winter months more than paid the cost of snow removal. An advantage from the standpoint of the highway departments is that with snow removal there is now year-round employment for highway maintenance organizations and equipment.

In Maryland, with an average annual snowfall ranging from 14 in. minimum to 70 in. maximum, it became apparent to the State Roads Commission that highways to render the maximum service to the greatest number of people must be made usable every day in the year. They were not efficient as long as they were only seasonal roads. After considerable experimenting, Maryland found that the great amount of snow and hail that was allowed to remain did much damage to the roads. It was further shown that the cost of removing the snow, at least on the main lines, would entirely offset the cost of repairs to the surface in the spring. Therefore, in the winter of 1920-21, 500 miles of road were kept open and free of snow. This experiment was so successful that during the next winter the snow equipment, including both snow plows and drift fences, was doubled, and has since been steadily increased and improved until during last winter the entire road system of 2,500 miles was kept clear of snow and open to traffic every day.

Clearing snow is a very arduous task and requires the greatest amount of hardihood in the crews actually engaged in the work, combined with the best team work and concentration of effort. These men are called to work at any time during the day or night and often for long hours at a stretch. The colder the day or night or the more violent the storm, the more urgent the need for their services. Much credit is due these members of the state highway forces for the heroic part they play in keeping the roads open during the winter months and thereby enabling the wheels of progress to turn throughout the year.

Standard Signs.—Standardization of street, sign, and signal markings was one of the chief problems discussed at the recent annual convention of the American Engineering Council. The committee on street and highway safety is working on the problem of drafting a system of markings, which the council will seek to introduce throughout the country. The work is in line with recommendations of Secretary Hoover's Safety Conference and is expected to be an important step in the campaign to reduce the dangers of highway travel. The council hopes to devise a system that will make all street and highway markings intelligible at a glance to motorists from all parts of the country, and to eliminate many of the unnecessary markings now found on the roads.

Organization U. S. Bureau of Public Roads

Some interesting information on this organization of the Bureau of Public Roads is given in the recent annual report of Thos. H. MacDonald, chief of the Bureau.

"The organization of the highway force of the Bureau of Public Roads which is responsible for the work reported upon in this report consists of a headquarters staff of eight divisions under the chief of bureau in the Washington office. Three of these, the division of design, construction and bridges, constitute the staff which under the chief engineer and chief of bureau are responsible for the conduct of the Federal aid and forest road work. The division of control is responsible for all accounting, for statistics and records, and for investigations dealing with the economy and efficiency of road construction. The division of tests and research carries on all physical researches and makes routine tests of high materials. The division of highway transportation and economics conducts research along economic lines with particular reference to the economics of highway transportation. In addition there are the legal and editorial divisions performing obvious functions.

"In addition to this headquarters staff there is a field force through which direct contact is maintained with the several states in all matters relating to the Federal aid and forest road work. This force is headed by 11 district engineers with offices in Troy, N. Y.; Washington, D. C.; Montgomery, Ala.; Chicago, Ill.; St. Paul, Minn.; Omaha, Nebr.; Fort Worth, Tex.; Denver, Colo.; Ogden, Utah; Portland, Ore.; and San Francisco, Calif. The eight eastern districts report directly to the chief engineer at Washington; those with headquarters in Denver, Portland and San Francisco, report to the deputy chief engineer, whose headquarters are in San Francisco, and through him to the Washington office."

1,111 Attended Wisconsin Road School.—The 1927 Road School of the Wisconsin Highway Commission had a total registration of 1,111 which broke all previous attendance records.

Performance of Contract

Essential Details of Highway Contracts Outlined in Paper at 1927 Highway Conference, University of Michigan

By M. DE GLOPPER
Assistant Construction Engineer, Michigan State Highway Department

The subject of Contracts and Contract Performance, including their preparation in such a manner that the subsequent accomplishment of the requirements may be realized with mutual satisfaction, is one primarily dealing with the rights of man among his fellowmen. To assume contract liabilities it is required that the several parties shall observe certain formalities and that these formalities and their intentions be made a matter of record in order that interpretation may later be resorted to upon the basis of fact. That we may better understand the importance of the essential details of highway contracts it is advisable, in fact quite necessary, for us to acquire a general knowledge of the common business rights of man in order that our respective obligations and benefits may be defined and safeguarded.

Few Court Disputs on Highway Contracts.—The comparative absence of disputes in the courts in connection with the performance of highway contracts is a sufficient and gratifying testimonial to the high standard of our present contract practice as well as indicating the proper relationship of mutual understanding between the contracting parties which has resulted from the efforts of co-operation and a willingness to exercise fair dealing between men in the performance of their work. This satisfactory condition has come about through the increasing tendency of each party to look at the several parts of a contract through the eyes of his co-contractor as well as through his own and this desirable action has materially resulted in eliminating the mist of misunderstanding which enveloped early contract operations. It is now generally understood that no rights can exist without a corresponding obligation and duty and with this knowledge comes a realization that somewhere along the line each person must pay for what he receives. In other words, the law dictates the principle that no man can expect something for nothing.

Commonsense of Everyday Usage.—The entire subject of contracts and specifications is one of comparative simplicity providing the mind is kept open to honest consideration and the desire for understanding. The confusion that prevails to some extent through the belief that a man's rights are delegated by and through the law in a manner and measure different from that practiced in our every day business and social intercourse should be dispelled from the mind seeking enlightenment. This confusion is the result, perhaps, of the necessary intrenchment behind legal terms in order to maintain regularity and prevent contradiction in meaning. A genuine understanding of the terms of the contract will, however, dispel all fear of the law and the legal phraseology commonly used may then be interpreted into the common sense of every day usage. We cannot nor need not, transpose the mind of the lawyer to that of the engineer, neither should we ever attempt to divorce the assistance of legal counsel. In the final analysis, however, we find that real intent and mutuality are the dominating influences behind a valid contract and these conditions can only be met by a realization and admission that every man has certain inherent rights in every day life and bargaining which must be respected through the application of the principles of common sense. In the absence of these principles and influences in the minds of the contracting parties no lawyer could or would attempt to establish or reduce to writing a statement or contractual conditions worthy of the name of a contract.

What the Contract Is.—In substance, the contract itself consists of three parts. The covenant, or legal part, which is usually prepared by legal counsel, covers a statement of the facts that for a certain consideration a certain piece of work will be performed in accordance with the rules set forth for such performance. The second part, covering the specifications, is a detailed explanation of the general governing provisions, the purpose of which is to denote what is desired on the part of the owner, how the work is to be controlled and what the relations of the parties shall be toward each other and toward the public. The third part, supplementary to the specifications, is the detailed plan of the work to be performed in which the requirements of work items is presumed to be as complete as is possible from all the possible source of available information.

By definition the contract is an agreement of mutual understanding entered into between two or more competent parties covering the full acceptance of a legal offer for a proper consideration. This implies the satisfaction of the four essential features which must be found in every contract, namely, (1) Competency of the parties, (2) Legality of the subject matter referring to the nature of the work to be performed, (3) Proper consideration in return for the performance of the work, and (4) Mutuality of understanding and intention. The first two conditions or essentials, competency and legal subject matter, need no further explanation as these matters are of common knowledge in the particular work in which we are interested. Likewise, the condition of consideration is one in which there is little or no disparity in as much as the amount of money to be paid for the work is a point of common understanding and is based upon the willing and full acceptance of the offer under consideration. The perfection of this essential does, however, demand the exercising of completeness in the statement of conditions which it is anticipated will be encountered and require that no information be withheld which is known to the one party and should be made available to the other. With this condition satisfied it is only necessary for us to know that the consideration agreed upon is a proper one and the question of adequacy is one only for local determination in connection with public policy providing of course that it comes within the bounds of reason and is reasonably equivalent to or commensurate with the obligation assumed. The only question which might arise as to the third essential is in its relation to the fourth and most important requirement, namely, the mutuality and intention of the contracting parties. This implies the necessity of a genuine agreement or the concurring of the minds in the same opinion, purpose or understanding.

Basic Principle of Contract Law.—Here we face the fundamental and basic principle of contract law. The other conditions refer to people or material factors but in mutuality we are concerned with the mind of man and the analysis is more difficult. It is impossible to enter into a person's thoughts to ascertain what he is thinking of or how fully he comprehends what he is doing or what he intends to do. Direct proof being therefore impossible, how can we approach the fulfillment of this condition? How can we answer the question as to whether there was a proper relationship of mutuality, a real meeting of the minds? The only possible way to meet this condition, it seems, is through and by careful and honest preparation of the contract in all its parts. If the interested parties were able to place the proper reliance in each other as to integrity, understanding and intention, with a feeling that the agreement could be carried out without violation, there would be less necessity for a knowledge of the legal requirements and perhaps the expressed contract could be dispensed with entirely. But the magnitude of the conditions effecting the performance became more complex because of the commercial nature of our work and for that reason the need of a written record of our desires and in-

tentions becomes necessary in order that the assent of both parties may be definite, unconditional and unqualified.

The Purpose of the Contract.—The purpose then of the contract, and more particularly the section covering the specifications, is to provide a means of recording what the intention was or reasonably should have been at the time the contract was made and signed. The rights of the parties are thus established not alone as a declaration of the understanding and intention existing before the work was started but as a record to form the basis of settlement of disputable conditions arising during the performance of the contract. The importance of this feature of highway procedure and administration must appeal to you as being worthy of careful thought and attention. The schedule of work items must be complete as far as it is possible to make it so and should cover such items as may reasonably be expected to be encountered during construction; the specific clauses, explanatory of these items, should be thorough and conclusive as to requirements; the full and complete relationships of the parties should be established beyond question and with fairness; and the procedure should be defined with respect to the settlement of any controversies which might arise affecting the status of the agreement or conflicting with the condition of the real intent of the parties.

Clarity Necessary.—In order to achieve this result the observance of a few elementary and common sense rules will serve to relieve the uncertainty as to mutuality and the consequent intention of the parties. Of first importance is the necessity of clarity. What is worth specifying is worth inserting in such a manner that any person of the average intelligence may readily understand the intent and purpose and may be in a position to give full assent of accord. If clarity requires the sacrifice of brevity then there should be no hesitation in making the sacrifice. It is true that a volume could be written on any one of the many specification clauses but the rules of common need and understanding do not demand this. It is sufficient when the requirements have been so expressed with conciseness that there can be no reasonable doubt as to its meaning. Nothing should be left to guess at. In the early days a contractor's definition of a specification intimated that it was a set of rules for the contractor's use in guessing at the engineer's meaning. This condition has been eliminated and with it has gone practically all of the lack of mutuality. The omission of ambiguous, inconsistent and contradictory clauses especially in such instances where repetition is necessary; the correlation and grouping of the clauses under the proper headings so that the intent is conclusively and unquestionably shown as to which clause is intended to cover any specific item; and through it all the display of thoroughness in properly treating all the requirements in their entirety without carelessness of expression or ignorance of the facts, these conditions will make possible the assurance of satisfactory performance during construction without expectation or need of charity or sacrifice to either party. In this way, and in this way only can intention be stated potently so that it will be effective. Comprehensiveness will come with completeness and the willingness to share obligation along with benefits will result favorably in the success of the contractual relations.

The burden of performance is on both sides. There is just as much of an obligation on the part of the contractor to inquire into these factors and to familiarize himself with the conditions as there is on the part of the contract writer to make his every want known and understandable. There must be a perfect balance throughout the agreement of equity, risk, benefit and satisfaction. There is no discharge of responsibility until the consummation of the contract and until that period has been reached the spirit of co-operation must permeate every thought, plan and action in the interest of completing the job with mutual satisfaction and in accordance with the real intent.

The Matter of Contract Time.—There are two other interesting phases of contracts which are essential requisites. The matter of time imposes a condition upon the contractor which is second in importance only to the nature of the project itself. It has been often said that time is the essence of the agreement, meaning that is the idea of the action and the law or the constitution of its being. Without the imposition of the time element the quality of the contract is lost. It satisfies the condition that we not alone want the thing itself but that we want it when we want it. In order to achieve this result we resort to the use of progress schedules in order that a comparative check may be had upon the speed with which the performance is being accomplished. In this matter we must also adopt the policy of firmness in the face of incapacity and of compromise against the presence of unavoidable delays. In this connection we again meet the need of co-operation as well as of insistence that our desires be respected.

The Surety Requirements.—The remaining feature of interest pertains to the surety requirements in which the bondsman gambles that the contractor will complete the work faithfully and in accordance with the terms of the contract. The surety then becomes the indirect third party inasmuch as the agreement of indemnity is a contract collateral to the original construction contract itself. As it is not the purpose of this discussion to enter into the direct violative aspect of contracts the relationship existing between the parties will not be considered at this time. It will be sufficient to state that the surety obligation imposes the requirement of exercising due caution in the alteration of agreements affecting the status of the bond itself. As it is a protective instrument all care should be taken to safeguard our expressed rights in order that this protection will become real in case of default or breach of contract.

In conclusion it might be stated that our portion of the obligations in connection with the matter of contracts is clearly defined and through strict observance of the essentials outlined we may do much toward the satisfaction of successful performance. It then remains for the co-contractor to do his part in an honest and co-operative spirit. This net result will be better work, a more agreeable progress record, lower costs and finally a mutual benefit to all concerned.

Expansion and Contraction of Concrete

Interesting data quoted in Concrete and Constructional Engineering.

A microscopic examination of concrete under contraction reveals cracks about 0.01 mm. in width followed by cracks of a magnitude of about 0.04 mm. which are visible to the naked eye.

An ordinary 1 to 5 concrete, with a strength of 2,500 lb. per sq. in. at 28 days, shows the microscopic cracks with 0.1 per cent expansion. Cracks visible to the naked eye appear in plain concrete when the expansion is 0.14 per cent, and in reinforced concrete at the higher value of 0.18 per cent.

Recent experiments, described in "Zement," proved that the cracks appear at a much earlier stage than was formerly suspected.

The question of how to prevent cracks due to hardening is of great importance in the construction of concrete roads, tanks, and long slabs. It has been found that the alternation of wet and dry weather is responsible for changes in length of the magnitude of about 0.3 to 0.4 per cent. It is essential to keep the concrete damp while the hardening process is taking place. Concrete maintained damp exhibited a contraction of only 0.08 per cent, compared with 0.32 per cent for concrete which was allowed to dry.

Canada to Spend $35,000,000.—Canada will probably spend $35,000,000 on highways during 1927, according to a statement made at the American Road Builders' convention in Chicago, by Wilfred Lefebure, of the Dominion Highway Department.

Recent Developments in Highway Research

The More Important Recent Developments Reviewed in a Paper Presented at 24th Annual Convention of American Road Builders' Association

By E. F. KELLEY

Acting Chief Division of Tests, Bureau of Public Roads

Research, as applied to highway problems, has developed, almost within the last decade, from a minor position to one of recognized importance. The reasons for this are obvious and have been stated so frequently that they need no repetition here.

The selection of that type of construction which, for the particular conditions involved, will result in the most efficient utilization of available funds and materials, requires the proper evaluation of numerous variables, many of which are at present unknown quantities. The pressing need for accurate data as a basis for the scientific evaluation of these variables is receiving ever increasing recognition, with the result that research programs are now being prosecuted by numerous agencies and the aggregate number of research projects under way is surprisingly large.

With so many investigators in the field, releases of valuable data are of frequent occurrence and it is impossible to review here all of the many recent developments of importance. Rather it is the intention to present a brief summary of the significant results developed by a few of the researches in which the U. S. Bureau of Public Roads has been concerned.

Motor Truck Impact.—A primary requisite for the design and maintenance of highway structures is an accurate knowledge of the destructive forces to which they may be subjected. At the present time the motor truck is recognized as one of the more important of these destructive agencies. For a number of years the Bureau of Public Roads has been concerned in a series of investigations which have had for their object the determination of the impact forces delivered to road surfaces and bridge structures by motor trucks, the factors influencing the magnitude of these forces, and the effect of these forces on the structures involved.

One series of tests, conducted co-operatively by the Bureau of Public Roads, the Society of Automotive Engineers and the Rubber Association of America, was undertaken to determine the in the cushioning qualities of the tires, speed of vehicles, roughness of the road surface and certain other variables, on motor truck impact. The investigational program has not been completed but some of the results are now available.[1]

[1]Motor Truck Impact as Affected by Tires, Other Truck Factors and Road Roughness, by J. A. Buchanan and J. W. Reid, Public Roads, Vol. 7, No. 4, July, 1926.

The impact road reaction depends on the four major variables—wheel load, truck speed, tire equipment and road roughness. Other variables exert some influence but, in general, these four are the important ones. An increase in load, speed, or roughness, or a decrease in the cushioning qualities of the tires, results in increased impact reactions.

Two Component Forces.—The force of the blow which a truck wheel delivers to a road surface is made up of two component forces. One of these is due to the acceleration or deceleration of the unsprung truck weight (that is, the weight of the parts below and not supported by the truck spring), and the other is due to the spring pressure on the axle at the instant of impact.

For normal operating conditions the unsprung component is the major quantity and this is especially so in the case of solid tire equipment. Many of the tests with solid tires showed the unsprung component to be as much as 90 per cent of the total reaction at ordinary operating speeds. (Fig. 1.) From this it may be inferred that cushioning devices above the truck springs should have relatively little effect on the road reaction, although the riding qualities may be appreciably affected thereby.

The magnitude of the impact force is dependent upon the type and condition of the tire. Worn out solid, new solid, new cushion and pneumatic tires, in the order named, produce impacts of decreasing magnitude. For instance, un-

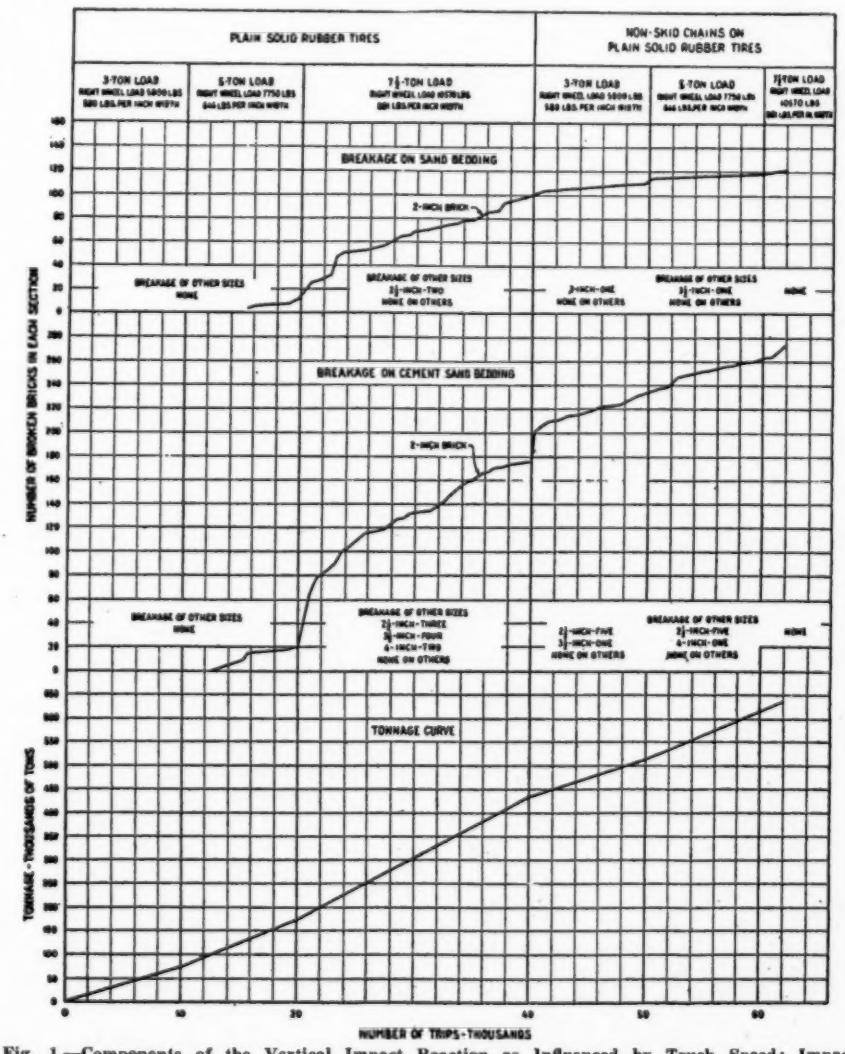


Fig. 1.—Components of the Vertical Impact Reaction as Influenced by Truck Speed; Impact Reaction—Per Cent of Static Load; Height of Obstruction—Inches

der certain test conditions in which 2-ton trucks were operated over artificial obstructions at a speed of 12 miles per hour, the measured impact reactions, expressed as percentages of the static load, were as follows: Worn out solid tires, 680 per cent; new solid tires, 370 per cent; new cushion tires, 240 per cent; pneumatic tires, 140 per cent. (Fig. 2.)

Thick Tire Rubber Reduces Impact.—Increasing the thickness of the tire rubber has been shown to have a marked effect in reducing impact. An appreciable variation in the cross-sectional rubber, or breaks in its continuity, result in heavy and repeated impacts and this leads to the recommendation that dual tires be mounted with the tread designs staggered.

For the conditions under which these tests were conducted maximum impact reactions occurred at critical speeds of between 12 and 15 miles per hour.

It will be of interest to those who are accustomed to think of impact as a percentage of the static load to note that, while the impact force increases

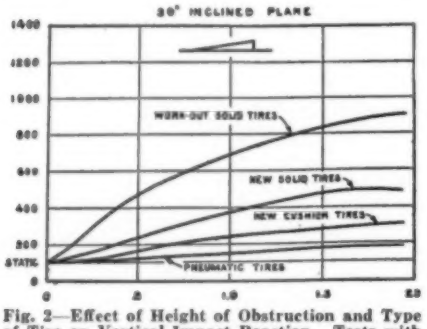


Fig. 2—Effect of Height of Obstruction and Type of Tire on Vertical Impact Reaction. Tests with 2-Ton Truck Equipped with Rated-Size Dual Tires, Loaded to Tire Capacity and Operated at a Speed of 12 Miles Per Hour

with increase in the wheel load, the percentage of impact, or the ratio of impact to static load, actually decreases. This may be attributed largely to the major effect of the unsprung weight, already mentioned, and the fact that the ratio of unsprung to total weight decreases with increasing gross loads.

Study of Road Roughness.—One of the most interesting phases of this investigation has been the preliminary study of the effect of road roughness. Test trucks were operated on two pavements having a marked difference in surface roughness and the results show that poor tire equipment may be exceptionally severe even on a smooth road, while good tire equipment considerably reduces the impact effect on a rough road. For instance, for a certain test condition in which 2-ton trucks loaded to rated tire capacity were operated at a speed of 12 miles per hour, the impact reaction which occurred on an average of once in every 10 ft. of road length showed the following relationship: On the smooth road this reaction exceeded the static load by 5 per cent for pneumatic tires and 45 per cent for worn out solid tires; on the rough road the excess over the static load was 40 per cent for pneumatic tires and 270 per cent for worn out solid tires. (Figs. 3 and 4.) The advantage of smooth pavements, aside from considerations of riding qualities, is thus emphasized.

To provide data which may serve as a basis for design and for the intelligent drafting of motor vehicle regulations, this portion of the investigation has been extended to determine the impacts which variations in load, speed and tire equipment may be expected to produce on pavements of various types and degrees of roughness.

Another interesting phase of the impact investigation was the comparison of the reactions produced by 4 and 6-wheel trucks. This indicated that the unsprung components of the impacts produced by a 6-wheel truck are approximately one-half those produced by a 4-wheel truck carrying the same load.

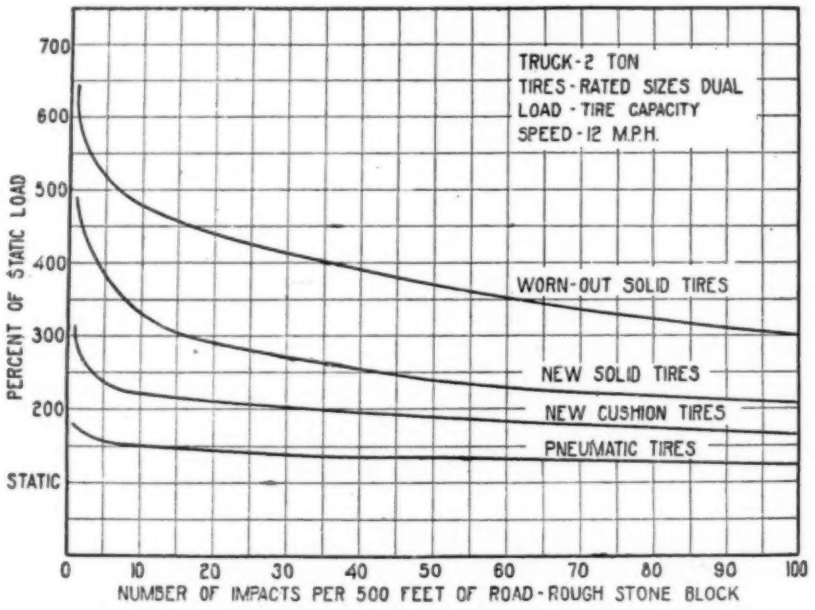


Fig. 3.—Influence of Tires on Vertical Impact Reactions on Rough Stone Block Road

(Fig. 5.) These results are a corroboration of previous tests[2] pavement by a 6-wheel truck are approximately one-half as great as those produced by a 4-wheel truck carrying the same which showed that the resultant stresses produced in a concrete load. The significance of these results lies in their indication that vehicle development may make possible the truck transport of greatly increased gross weights without a corresponding increase in the destructive effect on pavements.

Load Limitation Requires Knowledge.—The development of the data which will permit us to forecast with some accuracy the impact forces which may be developed under certain conditions does not, of itself, afford a solution of the whole problem since our primary object is scientific pavement design. The design of new construction and the limitation of loads on existing pavements to those which they can support with safety requires a knowledge of the stresses produced in road surfaces by impact forces. Considerable information along this line has already been developed, [3], [4], [5], [6], but much still remains to be done.

In a previous investigation[5] of the stresses due to impact in concrete pavements it was noted that unusually high unit stresses were developed. At elastic failure of the concrete under impact loads, tensile stresses were recorded which were at least twice as great as would ordinarily be expected to produce failure under static load. These results seemed to indicate that it might be permissible to use higher unit stresses in designing for impact forces than would be safe for static loads.

Stress Information Is Important.—The importance of securing conclusive evidence on this question will be recognized and such evidence has been made available[7] in the results of a co-operative investigation by Johns Hopkins University and the Bureau of Public Roads. These tests, while corroborating the results of the earlier investigation, have shown conclusively that higher unit stresses than would be used for static load design may not be used with safety in designing for impact loads.

Concrete beams subjected to static

[2]The Six Wheel Truck and the Pavement, by L. W. Teller, Public Roads, Vol. 6, No. 8, October, 1925.

[3]Highway Research in Illinois, by Clifford Older. Transactions American Society of Civil Engineers, Vol. LXXXVII, 1924.

[4]Tests of Impact on Pavements by the Bureau of Public Roads, by C. A. Hogentogler, Public Roads, Vol 4, Nos. 6 and 7, October and November, 1921.

[5]Impact Tests on Concrete Pavement Slabs, by L. W. Teller, Public Roads, Vol. 5, No. 2, April, 1924.

[6]Report of Highway Research at Pittsburg, California, 1921 and 1922.

[7]Static and Impact Strains in Concrete, by J. T. Thompson, Public Roads, Vol. 7, No. 5, July, 1926.

load showed a considerable lower modulus of rupture than exactly similar beams subjected to successive impacts of increasing magnitude when each of these impacts was applied but once. Under these conditions the beams were capable of withstanding greater elastic deformation under impact than they were under static load.

However, when the beams were subjected to repeated applications of impacts of the same magnitude, it was found that the greatest impacts which they could withstand without failure were those which produced a tensile stress equal to about 55 per cent of the static modulus of rupture. Other investigations of the fatigue limit under static load[8] have shown that concrete may be safely subjected an indefinite number of times to a stress equal to about 55 per cent of its ultimate strength. From this it may be considered that the behavior of concrete, when considered from the standpoint of fatigue limit, is very similar under both impact and static forces.

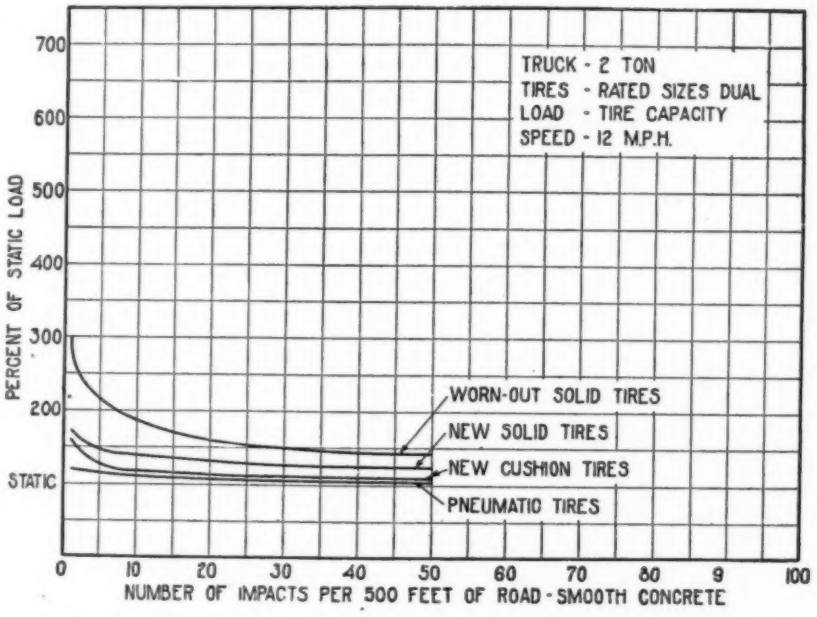


Fig. 4.—Influence of Tires on Vertical Impact Reactions on Smooth Concrete Road

Investigation of Bridge Impact.—The discussion of motor truck impact would not be complete without reference to the investigation of impact in highway bridges which for several years has been carried on co-operatively by the Iowa Engineering Experiment Station, the Iowa Highway Commission and the Bureau of Public Roads.[9]

For years the question of the proper impact allowance for which provision should be made in the design of highway bridges has been the subject of lively discussion among bridge engineers. No scientific data, applicable to modern loadings, has been available and of all the impact formulas which have been developed and used, none has been founded upon a more logical basis than the personal opinion of its author.

The bridge impact investigation was undertaken to throw some light on this question, and, though still far from complete, it has demonstrated conclusively that impact stresses of considerable intensity are produced in bridge structures by the passage of motor trucks. As in the case of the motor truck impact tests previously discussed, this investigation has shown that the impact increment of stress is due very largely to the unsprung weight of the truck and, therefore, that the percentage of impact decreases with increases in the total truck load.

Tests Confined to Floor Systems.—The tests have been confined largely to the floor systems of bridges. Floor beams and stringers supporting concrete floors have been shown to be subject to an impact increment of from 15 per cent to 100 per cent of the static stress, depending on the condition of the floor as regards roughness or obstructions. Even higher percentages of impact have been observed in the floor systems of timer-floored bridges.

It may be remarked that there are still no data available which may serve as a logical basis for an impact formula to be applied in the design of truss members.

The importance of the motor truck in highway transport is a measure of its importance in the highway research program. The data yielded by past researches are very largely qualitative and, to a great extent, we must look to the future for the quantitative results which are so necessary. The unsolved problem of major importance is the accurate co-ordination of the truck and the pavement.

Investigation of Thin Paving Brick.—The increase, during the past few years, in shipments of paving brick of less than 3 in. in thickness has reflected the growing opinion among engineers that the thinner brick may be adequate for pavement construction. The statistics submitted to the Permanent Committee on Paving Brick Simplification of the Department of Commerce show that the shipments of 2½-in. plain wire-cut brick amounted in 1923 to 2.7 per cent, in 1924 to 4.4 per cent, and in 1925 to 8.9 per cent of the total shipments of vitrified paving brick. In 1925 the shipments of two of the four sizes recognized as standard fell below those of 2½-in. brick.

In order to secure a measure of the comparative value of paving brick of various depths, particularly those 3 in. or less in depth, the Bureau of Public Roads has conducted an extensive investigation, the results of which have been reported recently.[10]

The investigation included an accelerated traffic test on brick wearing surfaces of varying thicknesses, supplemented by a field survey of several million square yards of thin brick pavements which had been in use a sufficient length of time to demonstrate their serviceability.

The Accelerated Traffic Test.—In the accelerated traffic test it was desired to eliminate all variables due to base construction and to test the brick as a wearing surface on an adequate foundation. For this purpose there was available a reinforced concrete circular track 6 in. thick, 13 ft. wide and about 1/10 mile in circumference, which had been used in previous tests. On this base were laid the ten test sections, which included five thicknesses of brick (2, 2½, 3, 3½ and 4 in.) and two types of bedding course (plain sand cement-sand). The joints in the brick surface were filled with asphalt. These pavement sections were subjected to an accelerated traffic test of 62,200 passages of loaded motor trucks, the loads on these trucks ranging from 3 to 7½ tons. A total of approximately 630,000 tons of truck traffic was applied to each section during the period of the test and of this approximately one-third was carried on trucks equipped with heavy tire chains. All of this traffic was concentrated in two 30-in. lanes or wheel paths. Based on traffic surveys, it is estimated that this accelerated traffic was equivalent to the average traffic of 3 to 7½-ton trucks on the highway system of Cook County, Illinois, during a period of 18 years. The behavior of the test sections was

[8]Fatigue of Concrete, by H. F. Clemmer. Proc. A. S. T. M., Vol. 22, Part II, 1922, p. 415.
Fatigue of Concrete, by W. K. Hatt, Proceedings Fourth Annual Meeting, Highway Research Board, National Research Council, December, 1924.

[9]Preliminary Impact Studies, by Almon H. Fuller, Bulletin 63, Iowa Engineering Experiment Station.
Experimental Impact Studies on Highway Bridges, by Almon H. Fuller and Robert A. Caughey, Bulletin 75, Iowa Engineering Experiment Station.

[10]Thin Brick Pavements Studied, by L. W. Teller and J. T. Pauls, Public Roads, Vol. 7, No. 7, September, 1926.

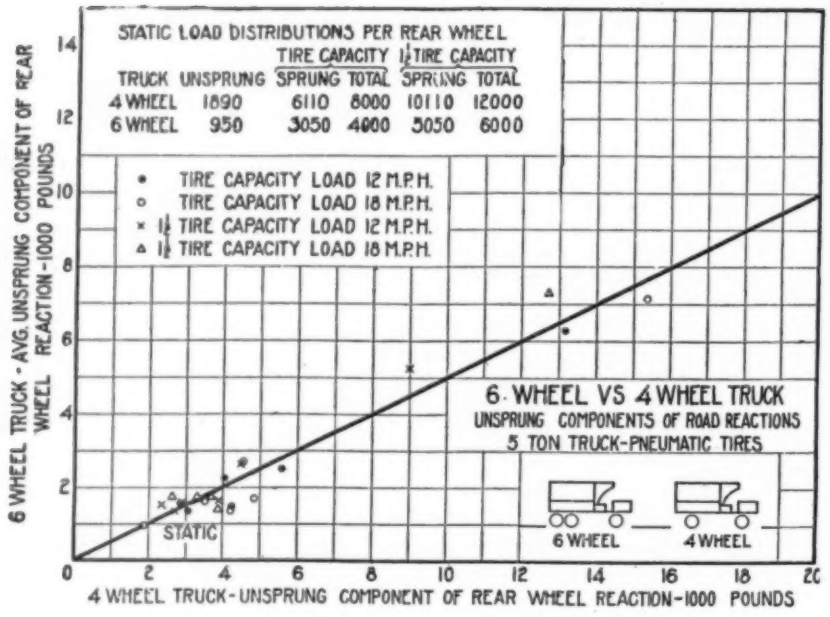

STATIC LOAD DISTRIBUTIONS PER REAR WHEEL
TRUCK UNSPRUNG TIRE CAPACITY SPRUNG TOTAL 1½ TIRE CAPACITY SPRUNG TOTAL
4 WHEEL 1690 6110 8000 10110 12000
6 WHEEL 950 3050 4000 5050 6000
TIRE CAPACITY LOAD 12 M.P.H.
TIRE CAPACITY LOAD 18 M.P.H.
1½ TIRE CAPACITY LOAD 12 M.P.H.
1½ TIRE CAPACITY LOAD 18 M.P.H.
6 WHEEL VS 4 WHEEL TRUCK
UNSPRUNG COMPONENTS OF ROAD REACTIONS
5 TON TRUCK-PNEUMATIC TIRES
STATIC
6 WHEEL
4 WHEEL
6 WHEEL TRUCK - AVG. UNSPRUNG COMPONENT OF REAR WHEEL REACTION-1000 POUNDS
4 WHEEL TRUCK-UNSPRUNG COMPONENT OF REAR WHEEL REACTION-1000 POUNDS

Fig. 5.—Impact Relations of 6-Wheel and 4-Wheel Trucks

compared largely on the basis of the number of brick broken during the progress of the test. It should be understood, however, that while transverse breakage was taken as a criterion of service, this breakage did not materially affect the actual serviceability of the test sections. The results of the accelerated test are shown graphically in Fig. 6.

Conclusions from the Test.—The most important conclusion derived from this investigation is that 2½-in. brick of the quality used in the tests, when supported by an adequate base, are satisfactory for pavements carrying heavy traffic. Also that 2-in. brick of similar quality and properly supported are adequate for pavements carrying the lighter types of traffic.

The resistance to breakage of the 2½-in. brick was remarkable and, for the particular conditions of this test, was only slightly less than that of the thicker brick. In the 30-in. wheel strips which carried the traffic loads, only fifteen bricks were broken in the sections of 2½-in. brick. One brick was broken in the 3-in. sections, six in the 3½-in. sections, and three in the 4-in. sections. Three hundred ninety-eight bricks were broken in the 2-in. sections.

The Bates road test in Illinois[3] and previous investigations by the Bureau of Public Roads[4] have shown that bituminous-filled brick tops cannot be expected to add materially to the beam strengths of pavement bases. This seems obvious, since a flexible wearing surface which has no bond with the base can scarcely be expected to add to its structural strength. Therefore, it has been concluded that the base should be as heavy for one thickness of brick as for another. The field survey has shown that, in practice, changes in base thickness are seldom made to compensate for changes in brick thickness.

Must Adapt Base to Load.—The accelerated traffic test was designed to test the brick as a wearing surface and the foundation was more than adequate for the loads to which it was subjected. It is emphasized that if failures of brick pavements are to be avoided the base course must be designed to carry the loads. The base must be stable in itself, regardless of the thickness of the brick surface.

The accelerated test showed very definitely that the plain sand bedding course is superior to the cement-sand bedding. In the 2-in. brick sections the breakage which occurred on the plain-sand bed was less than one-half that which occurred on the cement-sand bed.

Cobbling or rounding of the edges of individual brick was shown to be due almost entirely to the use of non-skid tire chains. The amount of cobbling under chain-tired traffic was found to be directly affected by the distance between bricks, wide joints causing marked increase in the rounding of the edges. From this it is concluded that the spacing between bricks should be the minimum consistent with proper penetration of the bituminous filler.

Importance of Bedding Course.—As a result of the field survey it may be pointed out that the maintenance of a smooth-riding brick surface is largely dependent on a bedding course of uniform thickness and uniform compaction. The adverse effect of using too thick a bedding course or one of variable thickness is marked. The bedding course should not greatly exceed ¾-in. in thickness and its uniformity depends on the degree of accuracy with which the base course is finished. Another construction detail which deserves attention is the application of the asphalt filter. There is a general tendency to use an excessive amount of filler and this results in a rough pavement surface. It is important that the filler used be adapted to the climatic conditions and that only enough be used to fill the joints. The advantages of smooth pavement surfaces in improving the riding qualities and in reducing destructive impact effects justifies careful control of these construction features.

This investigation has yielded results which indicate the possibility of very appreciable reductions in the cost of brick pavement construction. By the use of thinner brick very large aggregate savings may be effected and the value of the investigation as it may influence economy of construction is immediately apparent. For this reason the tests have had a particular interest since the benefits derived from them may be computed rather accurately in terms of money value. This is a characteristic not too common to research projects.

Demonstrated Value of Thin Brick.—The accelerated test demonstrated the value of thin brick as a pavement surface but it did not demonstrate that the

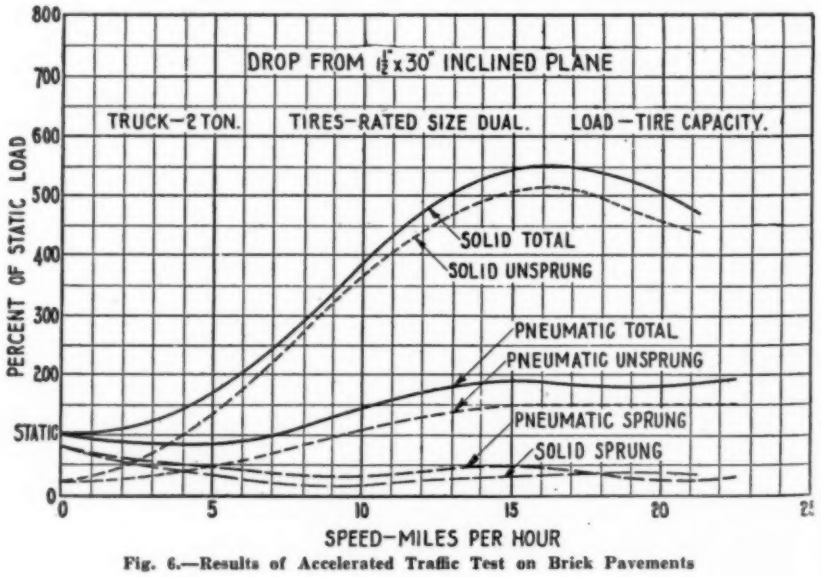


Fig. 6.—Results of Accelerated Traffic Test on Brick Pavements

thin brick is necessarily the equivalent of the thicker brick commonly considered as standard in pavement construction. The use of thinner brick undoubtedly reduces the factor of safety and for this reason the maintenance of a uniformly high standard of quality is essential if advantage is to be taken of the indicated savings.

Several types of base have been observed to render satisfactory service under rather severe traffic conditions, but in this connection it should again be emphasized that the first requisite of any brick pavement is a foundation which is stable, no matter what its type may be.

Conclusion.—The above constitutes a brief review of a few of the more important recent developments in highway research. Many other projects, equally important, are now in progress or contemplates.

The need for immediate information on many subjects has resulted in the simultaneous institution of many researches; so many, in fact, that to the casual observer, a present summary of investigations completed or in progress may seem a confusing list of apparently unrelated subjects. Each of these is a detail of an intricate design and eventually will be fitted into its proper place. However, we have barely started on the program which has for its object the development of the new science of highway engineering. The work which has already been done, valuable as it is, is relatively insignificant when we consider the stupendous task which lies ahead.

Robert Campbell Stubbs, Inventor, Dies

Robert Campbell Stubbs, founder of Vibrolithic concrete and Interlocking bituminous pavements, died in a hospital at Dallas, Texas, July 9th, at the age of 57 years, following an attack of pneumonia and complications.

Mr. Stubbs was born in Smith County, Miss., September 4th, 1869. In 1879 he moved to Bosque County, Texas, and later to Dallas, Texas, where he has made his home for the last forty years. He was a member of one of those sturdy pioneer Southern families which did so much for the Southwest during the years which immediately followed the Civil War. His father, the late Major G. W. Stubbs, was at one time president of the Mississippi State Senate.

Mr. Stubbs was a tireless student. His profound studies and unlimited capacity to absorb knowledge made him a national authority on concrete long before this material came into general usage. Most of his life was devoted to the construction field. In 1887 he and his father became engaged in general contracting. Later they branched out into the construction of sidewalks and pavements, being pioneers in the Southwest in the building of concrete sidewalks. From this early association with the construction of concrete sidewalks and pavements, Mr. Stubbs gained his knowledge of concrete pavement which led up to the founding of Vibrolithic, and later, to the development of Interlocking bituminous pavement. Mr. Stubbs was a charter member of the American Concrete Institute.

He was a devout Presbyterian and at the time of his death he was deacon in the First Presbyterian church at Dallas. Besides a host of local friends, as well as countless friends and acquaintances throughout the construction world, he leaves a wife, a son and daughter, a sister and two brothers to mourn his loss.

City Managers to Meet at Dubuque

The Fourteenth Annual Convention of the International City Managers' Association will be held on September 13, 14 and 15 at the Hotel Julien Dubuque, at Dubuque, Ia. The following program has been announced:

Tuesday morning, September 13. 9:00 a. m. (Central Standard Time.)

Registration: Mezzanine Floor.

Convention Assembly: 10:30 a. m.

Address of Welcome: Hon. Harland G. Melchoir, Mayor, Dubuque, Ia.

President's Response and Annual Address: President Fred H. Locke, City Manager, Grand Rapids, Mich.

Executive Secretary's Report.

Get Acquainted Luncheon: Julien Dubuque Dining Room, 12:15.

Tuesday afternoon, 1:30 p. m., September 13. Business meeting and reports of committees. General assembly and discussion of police administration. John N. Edy, city manager, Berkeley, Cal., presiding. Paper: Police Department Administration, by August Vollmer, chief of police, Berkeley, Cal. Chief Vollmer has an international reputation and is considered the outstanding authority on this subject. His paper will be discussed by Louis Brownlow, former commissioner of public safety, Washington, D. C., and former city manager of Petersburg, Va., and Knoxville, Tenn.

Tuesday evening, September 13. There will be a dinner dance. Each delegate is invited to bring his wife and friends.

Wednesday morning, 9:00 a. m., September 14. Round table: Street Widening for Solving Traffic Problems. C. A. Bingham, West Palm Beach, Fla., presiding. Paper by O. E. Carr, city manager, Fort Worth, Texas. Round table: Problems of the City Manager in a Small City. L. A. Goines, city manager, Alliance, Nebr., will preside. Paper by F. R. Buechner, city manager, Gladstone, Mich.

10:45 a. m. The Technique of City Management. R. W. Rigsby, city manager, Durham, N. C., will give a paper on this subject. It will be discussed by C. H. R. Fuller, city manager, Chatham, Ont. This is the most important round table of the convention.

Wednesday noon, luncheon 12:15. A national authority on city planning and zoning will give an address which will be discussed by R. W. B. Hart, city manager, Lynchburg, Va. W. R. Hopkins, city manager, Cleveland, O., will preside.

Wednesday afternoon, September 14. Tour of the city and visits to municipal enterprises. The ladies will accompany.

Wednesday evening. Annual banquet.

Thursday morning, September 15. 9:00 a. m. Round table: Fire Department Administration. E. E. McAdams, city manager, Waco, Texas, presiding. Paper: Joseph W. Fisher, fire chief, Dubuque, Ia., former fire chief of Nashville, Tenn. Discussion by Earl C. Elliott, former city manager of Wichita, Kans. Round table: Parks, Playgrounds, Swimming Pools. Presided over by A. M. Wilson, city manager, Colorado Springs, Colo., and vice-president of the association. Paper by A. E. Davidson, director of public welfare, Grand Rapids, Mich.

Thursday afternoon, September 15. Business session.

High Head Pumping on Paving Job

The necessity of securing water for the Mountain Springs paving job in San Diego County, according to June California Highway News, probably resulted in the establishment of a new record for the highest head encountered on any paving project in California.

It was necessary to secure water at Jacumba and to pump it over a summit 44 miles east, from which point it flowed by gravity to the work. The difference in elevation between Jacumba and the Summit Reservoir was about 417 feet. The amount of water required was estimated at 300 gal. per minute. The total elevation between the summit and the lowest point to which the water was carried for use was 1,753 ft.

The pumping to the summit was accomplished by means of a 2½ in. six-stage type MMB horizontal centrifugal pump with bronze impellers. The pump was operated by a 5⅜ in. by 6¼ in., 4-cylinder Waukesha industrial power unit with twin disc clutch power take-off. A 4 in. welded steel line was used to convey the water to the summit and this line crossed the highway 2-3 mile east of the pumping station, with two 45 degree angles.

In order to insure full discharge, a booster pump was located 2.6 miles from the first pump. This was a 4½ by 5½ Triplex pump, also driven by a Waukesha motor. The piping was so arranged, that the water could be passed through the pump or by-passed around it, which made it possible to operate either only the first pump or use both pumps at the same time.

Bituminous Penetration Pavement

Design Features and Methods of Construction Discussed in Paper Presented at Annual Convention of American Association of State Highway Officials

By E. C. WELDEN
State Highway Department of Connecticut

In the design and construction of bituminous pavements, may be included all classes of work in which bitumen in the form of asphalt or tar is used as an integral part of the pavement. Roughly they may be divided into two classes: First, those composed of mechanical mixtures, which in nearly all cases are laid hot and in which class is included sheet asphalt, topeka, and many of the patented pavements, such as warrenite, bitulithic, amiesite and others; second, bituminous macadam, in which the voids between the stone of the wearing course are filled with bituminous binder. Space will not permit of a lengthy discussion of all of the various types. Therefore, bituminous macadam, because of its adaptability, economy, simplicity and the availability of materials entering into its construction, will form the basis of this paper.

In the design of the pavement, whether it be of bituminous macadam or of some other type, the character and intensity of traffic should be given the most careful attention. A design that may be adequate and economical for one locality may prove an utter failure when built in locations and under conditions not adapted to its use.

Pavements, like structures, "are designed for a specific purpose," and every engineer whose duty it is to supervise their design should study, not only the probable loadings to which they will be subjected, but must also have an understanding of the internal forces resulting from these loads.

In the design of a bituminous macadam pavement, it should be borne in mind that there is little inherent stability in the pavement property. This fact necessitates intelligent design and careful construction of the foundation upon which it is to be placed, for it is in the foundation that the essentials governing the success or failure of the work will often be noted.

Foundation Course.—The carrying capacity of the pavement is influenced to a great extent by the moisture-content and character of the subsoil beneath. With very few exceptions this capacity is increased as the moisture content in the subsoil is decreased, and for this reason it is essential that adequate drainage structures be provided to reduce to a minimum the amount of free water beneath the pavement. This usually can be successfully accomplished by the use of standard drains placed on one or both sides of the road, as may be required.

In the case of very retentive soils not easily drained, increased stability may be obtained by the use of a layer of sandy gravel, cinders, or slag, spread over the surface to a depth of 6 in. or more. This treatment is not ordinarily expensive in localities where these materials are available and has proved very effective on roads that are not subjected to the frequent use of heavily loaded trucks.

There are, however, many locations where it will be necessary, because of local conditions and the intensity of traffic, to provide foundations of greater strength and thickness. This is usually accomplished by a layer of field stone broken and placed by hand, or by the use of coarsely crushed stone either from a local or commercial crushing plant.

Field stone when available is usually the more economical. The depth of this course will depend to a great extent on the character of the subsoil and the sizes of stone used. It is largely a matter of judgment on the part of the engineer, but will ordinarily range from 6 to 12 in. in depth.

This course, after being thoroughly rolled, should be filled with coarse sand or fine gravel and again rolled until firmly compacted. To foundations of this nature should be added a layer of crushed stone 2 to 3 in. in depth. This stone should be carefully spread to the required grade, rolled and filled to provide a uniform surface for the top course.

There are many sections where it is possible to secure gravel suitable for a base course from local deposits with a considerable saving in cost over the use of broken stone. A well graded gravel gives excellent results and has the advantage of presenting a more uniform surface for the use of the public during the construction of the road. It is good practice to carry the foundation course under the shoulders to the gutter line, thus insuring better drainage and greater stability for the pavement.

It will not always be found necessary to place a foundation course under bituminous pavements, there being many localities where the soil is of a permeable nature with sufficient bearing power to support the pavement and the super-imposed loads. If, however, there is any doubt as to its necessity, it is better to err on the side of safety.

Base Course.—In general, the design and construction of the base course is essentially the same throughout the eastern states. It usually consists of a compacted layer of crushed stone, 5 to 7 in. in depth, laid and rolled in two courses. The sizes of the stone used vary somewhat, depending upon its source. If obtained from a commercial quarry, well graded stone passing a 3-in. ring and retained on a 1½ ring will give very satisfactory results. If the stone is crushed on the job, greater latitude in the sizes used is not considered objectionable, although great care should be taken to prevent the smaller sizes forming in pockets due to segregation.

While the quality of the stone used in the base course does not need to be selected with the same care as should be exercised when choosing material for the top course, it should, however, be reasonably hard and structurally sound. Stone having a percent of wear of not more than 5 and that when crushed produces few flat or elongated pieces, may be safely used even in roads that will be subjected to reasonably heavy traffic. It is to be inferred that by heavy traffic is meant the gross weight per unit load rather than the number of units passing over the road.

Sand that is well graded and free from loam is considered an ideal filler for the base. Screenings are often used for this purpose and when obtained from rock of a low cementing value will usually prove satisfactory. Screenings obtained from trap rock and some of the lime stones are not considered equal to sand as a filler because of their impervious nature when compacted with the stone of the base course. The high cementing quality of this type of filler produces a hard, unyielding surface preventing any mechanical bond between the base and top course.

It has long been realized, both in the rigid and elastic types of pavement, that the edges constitute a point of weakness. To overcome this and provide greater lateral stability for the top course, it is recommended that the base course be constructed 6 in. wider on either side than the penetrated portion of the pavement. While this has not been the standard practice in the east and, at first thought, may seem an unnecessary expense, it is felt that this method of protecting the edges of the pavement from wear and settlement justifies the small additional cost. Not only will this additional material serve

as a support for the top but will be found equally valuable in strengthening the shoulders, thus affording greater resistance to traffic when shoulders are used by passing machines or as a parking space.

Top Course.—In considering the top course, it is highly important that certain factors be taken into consideration, for in this course are to be found many of the faults, as well as the good qualities, of this type of pavement. It is also here that are found the greatest differences in construction practice among the various states and municipalities. Among these differences may be mentioned the depth, physical qualities, and sizes of stone used; the quantity and character of bitumen; and the methods employed in incorporating these materials.

These differences of opinion have tended to produce anything but uniform results in the locations where these pavements have been most commonly used. It may, however, be noted that at the present time there seems to be a tendency to greater uniformity in many of the details so necessary in securing the best results in pavements of this type.

Size and Quality of Stone.—Without doubt the best results will be obtained through the use of crushed stone of large and uniform size. This size may vary somewhat with the hardness of the stone used. In the case of trap or other rocks showing a percent of wear not greater than 3, ideal sizes will be obtained by the use of stone passing a 2½-in. circular screen and retained on a 1½-in. circular screen.

The key stone recommended for use after the first application of the binder material should be the ordinary commercial ¾-in. size, obtained from passing through a 1-in. screen and retained on a ⅝-in. screen. For the second application, cover stone ranging in size from ⅝-in. to ⅜-in. is favored.

While the use of small stone ranging in size from ¼-in. to ¾-in. is sometimes specified to follow each application of bitumen, it is felt that better results will be obtained by using as key stone the commercial ¾-in. sizes previously mentioned, following the first application, because of the greater mechanical bond obtained.

Only stone that will show a per cent of wear not greater than 3 and a toughness of not less than 12 should be used in bituminous pavements that are to be subjected to exacting traffic conditions. Hard, tough rock that does not fracture or crumble under the roller can be more readily compacted to form a smooth interlocking top with uniform voids, than will be the case if softer or less uniform stone is used.

Uniformity of voids is of vital importance in securing an even penetration of bitumen. Pockets of small stone occurring either as a result of being crushed under the roller or from the use of stone improperly graded are productive of results detrimental to the smoothness of the pavement.

The stone for this course should consist of only clean, tough, durable fragments, free from flat or elongated pieces. It should be carefully and uniformly spread, after which it should be compacted by rolling until the fragments are keyed together to form a surface that will show little displacement under the roller.

Thorough Rolling Important.—The importance of thoroughly rolling the top course before applying the bitumen can not be too strongly emphasized. Too often this feature of the work is slighted.

The use of a 3-wheel roller weighing not less than 10 tons is recommended for this work as well as for all other work where a roller is specified.

While considering the adaptability of stone for the penetrated portion of the pavement, it may be well to call attention at this time to a condition sometimes present in stone that otherwise meets all the necessary requirements. I refer to the slippery or greasy character of some rocks that prevent a proper adhesion of the bitumious binder. This is a serious fault that will result in an inferior pavement if not complete failure. For the same reason, stone that is coated with dust or dirt is also objectionable and its use should be avoided.

In locations where it is not possible to secure ideal stone at a reasonable cost, inferior rock has often been used with very successful results in roads that carry only light traffic. When using the softer grades of stone, relatively larger sizes than those specified for trap or its equivalent are preferable.

After the stone has been carefully spread, it should be rolled only enough to secure a uniform cross section, since continued rolling will tend to crush the fragments, thus preventing a proper distribution of the bitumen. While too much rolling before applying the bitumen may be harmful, there is no question regarding the necessity of thorough and continuous rolling after the surface has been completed. If the weather is warm and the binder is in a more or less plastic condition, this rolling may be continued with beneficial results for several days.

Depth of Penetration Course.—The depth of the penetration course as ordinarily laid, varies from 2 in. to 3 in. in thickness depending to a great extent on the sizes of stone used and the amount of bitumen desired per square yard. Obviously, the depth should be increased as the maximum size of stone to be used is increased. Ordinarily, it is safe to consider that the minimum depth should be equal to the diameter of the screen through which the stone passes.

I feel that the best results will be obtained with the use of hard, tough stone ranging in size from 2½ in. to 1½ in. where a compacted depth of 2½ in. is desired for the top course. Care should be taken to use only enough stone to secure the desired depth after rolling. Too great a depth of stone will produce a surface that will not be properly filled by the bitumen, while insufficient stone will cause a condition in which the excess bitumen will tend to produce a surface that becomes wavy and picks up under traffic during hot weather.

After applying the bitumen and while it is still hot, key stone should be spread over the surface in sufficient quantity to fill the voids. Any excess stone that is not embedded in the bitumen after the surface has been rolled should be removed by the use of hand or power brooms before the second application. The condition of the surface before this application is important in its relation to the completed pavement. A surface that is covered with loose stone is not readily penetrated, resulting in a blanket of bitumen and cover stone. This condition does not give the most satisfactory service under heavy traffic.

Ideal Surface Should Be Smooth and Tight.—I am of the opinion that the ideal surface should be smooth and tight, presenting a mosaic appearance in which the upper surfaces of the larger stone are exposed to the action of traffic. Although this condition requires the use of high grade rock, I feel that the results attending its use justify its selection for all pavements of this type that are to carry heavy traffic. The mosaic condition referred to is not obtained until the road has been subjected to traffic from three to four years.

The amount of cover stone used on the second application of bitumen will depend to some extent on the temperature of the air and of the materials when the work is done. During the summer considerable more stone can be rolled into the surface than will be possible during fall construction. This stone should be uniformly spread. If bunches form, they should be removed by the use of brooms.

Key stone and cover stone should both be spread parallel with the center line of the road. This is not only productive of a better riding surface but will materially assist in preventing the voids becoming filled in the opposite half of the road when only a portion of the width is being penetrated at one time.

Practice has shown that with trap or an equally heavy stone, the amounts per square yard of surface for a 2½-in. top course are as follows: Coarse stone, 240 lb.; key stone, 50 lb.; cover stone, 38 lb. During the fall of the year the amount of cover stone that can be used to advantage will not exceed 25 to 30 lb. Anything in excess of this amount will be ground up or thrown to the sides of the road by passing traffic.

Bituminous Binder Material.—During the earlier years of the construction of this type of pavement, tar as a bitu-

minous binder was probably more commonly used than now. Present day practice seems to favor the use of asphalt, although tar with the softer stone has proved very successful on pavements where the travel is light.

In early construction work the bitumen was poured by hand from pots or applied by the use of a hose attached to a distributor tank. These crude methods have now been replaced by the use of motor driven pressure distributors equipped with heating units and insulated tanks. Perfected machinery has greatly increased the speed and quality of this part of the work.

There has been and still is a considerable variation in the amount and hardness of the binder used by various states. At the present time the general practice seems to favor the use of asphalts with a penetration between 85 and 100 for use in roads that are to carry heavy traffic. Asphalt having a penetration between 100 and 120 is commonly used in some locations where traffic is light and during late fall construction. The use of too soft an asphalt tends to promote corrugations in the surface of the pavement and to increase maintenance costs.

Should penetration construction be desired for locations where traffic is concentrated and extremely heavy, asphalt with a penetration between 60 and 70 is recommended. Binder of such low penetration will show little displacement under traffic even in the warmest weather, nor will it be affected by low temperature if travel is sufficiently heavy to develop the surfacing process before winter.

The amount of bitumen used should vary with the depth of stone in the top course. It may be generally stated that this amount will be equal in gallons per square yard at 60° F. to the depth in inches of the stone to be penetrated. In case of a 2½-in. top constructed of the sizes of stone specified, the use of 1¾ gal. of tar or asphalt per square yard for the first application is recommended, while for the second application ¾ gal. is sufficient. It should be borne in mind that a correction must be made in the yardage that will be covered with bitumen that has been heated, because of the expansion that takes place.

The binder material in the form of tar or asphalt should be heated to not less than 275° F. nor more than 350° F. for asphalt, and not less than 225° F. nor more than 300° F. in the case of tar.

If stone passing a 3-in. circular opening is used in the top course laid as suggested to a depth of 3 in., the amount of binder used should be increased to 2 gal. and 1 gal. for the first and second application respectively. These amounts of bitumen are too liberal where stone soft enough to break up under the roller is being used.

Effect of Seasonal Changes.—Any paper dealing with the construction of bituminous macadam pavements would not be complete without a word in regard to the effect of seasonal changes in the results obtained. Because of the great variation in climatic conditions between different states, no rule as to when top course construction should cease can be reasonably stated.

The surfacing process resulting from the action of heat and traffic can only be effective while the temperature is still warm enough to soften the binder material. A pavement that is laid during cold weather and opened to traffic has little chance of developing a smooth surface. The binder material is inclined to be brittle and the cover stones are easily dislodged by traffic and swept to the sides of the road carrying with them in many cases small particles of the bitumen. Surfaces that have lost much of the cover stone and some of the bitumen ravel easily and are not easily repaired. Late surfacing work should be avoided whenever possible. If it must be done and opened to traffic the surface should be kept well covered with a blanket of coarse sand during the winter months.

Conclusions.—It would be foolish to assume that any one type of pavement will give the best results under all conditions; to do so would be to court disaster and the necessity for the reconstruction of many projects.

Unstable subsoil conditions prevailing over long sections of road that can not be adequately drained offer very little support for a pavement of the penetration type. While the construction of elaborate drainage structures and the formation with permeable materials of a foundation course will to a great extent overcome the difficulty, it is felt that greater efficiency and economy may be obtained by the selection of some other type of pavement.

While it is true that careful consideration must be given to the selection of suitable materials and to the details of construction to secure the most successful results, these requirements are in no way peculiar to penetration macadam since "the same essentials are equally important in the construction of every other type."

Probably more has been learned from practice than from theory regarding the limitations of these pavements. Experience has shown that even when subjected to heavy truck traffic, bituminous macadam pavements that were properly constructed have functioned successfully for long periods of time with surprisingly low maintenance costs. It is no doubt true that many of the failures charged to this type of pavement are the result of improper design, unsuitable materials, or faulty construction, rather than to the depreciating action of traffic.

Pavements of this type have been designed to give economical and satisfactory results even though subjected to varying degrees of traffic. One has but to ride over some of the heavily traveled trunk line highways in the east, on which this type of pavement has been laid, to appreciate the traffic resisting qualities of bituminous macadam when designed to meet the maximum legal loads allowed by law, while their adaptability for use on residential streets is shown by the millions of square yards that have been laid in cities and villages throughout the country.

The following suggestions are noted for consideration in connection with the design and construction of bituminous macadam pavements:

1. The base course should be compact, tight, unyielding to the greatest degree, and rolled to a smooth uniform surface, since any unevenness in this course is almost sure to show up in the surface.

2. The thickness of the foundation depends largely on subsoil conditions and traffic requirements.

3. The selection of mineral aggregates and binder material of a character suitable to meet the requirements for the type of work to be done.

4. The discouragement wherever possible of late construction work on the penetration course.

5. Careful construction methods directed by engineers experienced in this type of work.

Resistance to wear, impact and abrasion, together with its adaptability for speedy construction and easy maintenance should increase the popularity and use of bituminous macadam pavements.

Texas Commission Has New Accounting System

Following approval by the Texas State Highway Commission of plans and surveys made by H. L. Washburn, auditor of Harris County and designer of a new system of accounting for the Highway Department, work has started on the inauguration of the system.

A certified public accountant has been employed to install the system under the direction of Washburn, and estimates are that the work will be completed in sixty days. The entire present system will be changed and practically abolished, and the new method will be built around a central unit to have complete charge over accounts in all divisions of the work.

Failure of the department to have a system whereby a full check could be kept on outstanding indebtedness and the amount of income due is said to be the main reason why further Federal aid was withheld from Texas about six months ago. Members of the commission declare fully justifiable accounts are continually coming to their attention that were incurred months ago, but nothing was known of them because of the muddled system.

The Maintenance of a State Highway System

Organization and Methods in Wisconsin Described in Paper Presented at 13th Annual Road School, Purdue University

By N. M. ISABELLA
Maintenance Engineer, Wisconsin Highway Commission

In the selection of the state highway system in Wisconsin, a very careful preliminary study was made of the whole state and its possible future development. The main routes were chosen from the best information available. This was followed by a careful reconnaissance survey in the field. Prior to final selection, hearings were held at all county seats where all interested had an opportunity to discuss and present their views as to the proper location in their community. In a great many cases changes were made as the outcome of the hearings and it is evident that by adopting this policy a system of highways was finally selected that fills the general traffic demands of the state. It was determined that the entire state system, whether improved or not, must be maintained from the very beginning. Undoubtedly this last named factor was the most important one in the development and improvement of highway transportation in Wisconsin. It is held that the establishment of a preferred system of highways by any unit of government should carry with it the immediate maintenance of that system by the establishing unit. It cannot be over-emphasized that a state system of roads should not be laid out unless real state control of its maintenance is also provided.

Factors on Which Efficient Road Maintenance Depends. — The maintenance of a highway is much different than the construction. In the building of a highway, definite factors are considered, such as alignment, grade, drainage structures, thickness and width of surfacing, and other details that vary with the locality. In maintenance the remedy or method applicable to one road does not necessarily apply to another. The problem is to keep the road up to its original condition insofar as funds will permit. The condition of the road varies with the type and character of the traffic, drainage, topography, weather conditions, and thus one cannot definitely say what the maintenance cost of a given road will be because these items cannot always be determined in advance. Efficient road maintenance will, therefore, depend on the following factors:

(1) Sufficient funds available.
(2) Organization and equipment.
(3) Proper planning and budgeting of funds to meet traffic demands.
(4) Efficient execution of the work as planned.

Taking item 1, namely, Funds Available, it must be said that to carry out the maintenance work successfully, sufficient funds must be provided. In most of the states, the funds used for maintenance work are derived from revenues collected from motor vehicle fees. The motor vehicle owner is becoming more critical each year in his requirements for highway service, and takes the opportunity of informing the highway official that he is paying the bill and desires that he be given just returns for the taxes paid by him.

Organization and Equipment: In addition to having sufficient funds to work with, it is very essential that the work be handled by a competent organization supplied with up-to-date equipment to do the required work properly.

Proper Planning to Meet Traffic Demands: The future demands of highway traffic must be anticipated from the best available information. Preparations for the year's work should be made well in advance. Probably one of the most undesirable features from the standpoint of the motorist is the closing of the main highway to traffic and requiring him to travel over a detour. If these are not planned for in advance, there is bound to be dissatisfaction from the motorist's viewpoint. The widening of roads for safety and surface treatments to eliminate the dust nuisance on gravel roads are important factors to consider.

Efficient Execution of the Work: After having sufficient funds available, the organization and equipment, and definite plans made to take care of traffic, the last item, and one of the most important, is the efficient execution of the work. This item is important because it involves the thought and energy of the men who actually carry out the work as well as the official in charge.

Importance of Systematic Maintenance.—In the maintenance of our highways in Wisconsin, we have tried to keep these items in mind and in planning our work the thing uppermost in the minds of the highway officials has been to render highway service at a minimum cost and to provide for the public a safe and comfortable highway. One thing upon which all opinions seem to be agreed is that the expenditure of large sums of money for construction is an extravagant use of funds unless followed by systematic maintenance. It, therefore, follows that in the design of a highway the maintenance factors should be considered. The cheapest highway in original construction cost is not always the most efficient and economical highway to maintain, and it is well for those in charge of design to keep these matters before them when planning for future highways. It often happens that the highway required by traffic conditions in a particular locality cannot always be constructed because of the lack of funds, but there should be no excuse for the official planning the wrong highway when all conditions are favorable. In other words, build the maintenance in the construction of the road. Maintenance work, while it is variable from season to season, can be efficiently executed if properly planned. There are no two roads with similar conditions as to traffic, topography, drainage, etc., and for this reason a special study should be made of the entire road system with the idea of planning for each individual section of the highway. Often, the expenditure of a few hundred dollars can save thousands of dollars at some later time, and these things can only be found by close observation of all conditions at hand, and by giving due consideration to all the items that will affect the maintenance cost.

In order that a maintenance organization may function efficiently, it must not be tied up in too much departmental red tape. There should be a governing head or body to all successful organizations, but in work which varies as much as the maintenance of a state highway system, the exercising of a certain amount of judgment and discretion must be left with the man actually doing the work and his immediate superiors. The general policies red tape. There should be a governing body, but the matter of details which vary with every locality and with every highway must necessarily be left to the maintenance man who actually carries out the work.

How the Maintenance Work in Wisconsin Is Carried On. — The maintenance work in Wisconsin is carried on somewhat differently than in most of the other states. While the work is under the supervision and direction of the state highway department, it is actually done by the county forces and to give the public efficient highway service, there must necessarily be very close cooperation between the counties and state. We are glad to say that this cooperation has been existent from the very beginning and has continued with increasing benefits. It has been our aim to plan the work for the succeeding year at the end of the maintenance season, at which time a representative of the state highway department, accompanied by the county

commissioner and county highway committee, go over all the state trunk highways in the county and determine the improvements to be made under gang maintenance on each highway. The general maintenance work, of course, is routine and the cost consists primarily of patrolmen's salary, supplies, repairs, and extra help. Gang maintenance work, which may be divided into reconstruction and betterment, requires semi-construction methods and must be planned for in advance. These projects are planned for and a definite amount of money is set up for each project. The county must agree to commence the work on a certain date and have it completed within a certain time. Usually the work is so planned that it will offer the least inconvenience to the traveling public. A good many of the gang maintenance jobs are completed early in the season before the heavy summer traffic starts and some of the work is done in the fall of the year after traffic has decreased considerably. We try to keep the work to a minimum during the months of July and August, which are considered the heavy traffic months.

In all highway organizations, there should not only be cooperation between the man who actually does the work and his superiors, but there should be thorough cooperation between the maintenance and construction departments. If traffic is to be served, it is necessary for those in charge of maintenance to be informed on what the contemplated construction projects are, their location and information as to whether detours will be necessary or not. The great bulk of highway construction is planned well in advance, and by knowing just where the projects will be located for the coming year, detours may be provided and improved by the maintenance forces before the road to be constructed is actually closed. We have followed this policy quite religiously in Wisconsin and can cite many instances where detour roads have been previously widened and surfaced to take care of the through traffic during the construction of the main road.

Maintenance work may be divided into four general classes, as follows: Spring maintenance, summer maintenance, fall maintenance, and winter maintenance.

Spring Maintenance.—Probably the most critical time in the maintenance of earth, gravel and other light surface roads is in the spring of the year when the frost is leaving the ground. It is true that spring conditions do not show their effect so much on a permanent or durable pavement, but when one considers the fact that the hard surfaced or paved road comprises only a small percentage of the rural highway mileage, the big problem lies in the proper maintenance of the gravel, shale, stone and earth roads. At the beginning of the maintenance season which is usually during the month of April, the ditches must be opened, the culverts cleaned out, the surface graded smooth, and repaired wherever necessary. Objectionable features must be removed from the right of way. At this time of the year it is also possible to do the best work in shaping the cross section of the road. The high places may be cut down and the low places filled. If the patrolman gets a good start in the spring, the maintenance of his section will not be a great task during the summer season, but if the important details are neglected during the spring, he is bound to have trouble during the summer months when traffic is at its maximum. It is sometimes impossible for a single patrolman to do all the work necessary on his section in the spring, and if this is true, he should be given extra help and in most instances a tractor-grader outfit should be run over his section to open the ditches. The guard fence, rip rap, etc., should be repaired.

Summer Maintenance.—After the details of spring maintenance have been taken care of, the patrolman's time is then required almost constantly on the surface of the road. From time to time, he will find it necessary to replenish the surface materials from the stock piles which have been provided. Where traffic reaches 500 or more vehicles per day on the ordinary dirt or gravel road, the patrolman finds that he must keep his grader constantly on the surface in order to provide a smooth riding road. If, for any reason, he leaves the road a day or two, it is very plainly noticeable. One of the important items during the summer months' work is the cutting of weeds along the shoulders, ditches and right of way. In some cases, two cuttings a season are sufficient, but we have found that in many cases it is necessary to cut the weeds and grass as many as four times. The months of July and August require the most intense maintenance on the surface for during these months the traffic is at its maximum. In Wisconsin it is not expected that the patrolman can do much more than keep the surface in a smooth riding condition during this period. Usually, extra work which is required on his section is taken care of by special crews.

Fall Maintenance.—In the fall of the year when traffic has decreased considerably, the patrolman will find more time to take care of work other than the surface. At this time the ditches should be opened again and all culverts cleaned out, and the weeds and brush cut from the right of way to prevent snow from drifting on the highway during the winter. Stock piles of materials should be provided at those places where the road is apt to give trouble in the spring. The road surface should be kept smooth so that when heavy frost comes, it will freeze in a uniformly smooth condition. It is very essential that the patrolman continue his grading operations until the ground becomes frozen.

Winter Maintenance.—In most states of the latitude of Wisconsin, the amount of winter maintenance done is comparatively small on account of snow conditions. Quite a number of states have adopted systematic snow removal programs and are attempting to give through highway service during the winter months. We believe the time is not far distant when well formulated programs for winter maintenance and snow removal will be put into practice in all states in the snow belt. The demand for through highway service during the winter months is rapidly growing. This is very plainly shown in Wisconsin by comparing the snow removal activities of last winter with that of this winter. During the season of 1925-1926 there were approximately 1500 miles on the snow removal program. About $100,000 was expended. Sixty miles of snow fence were placed. This fall $250,000 was appropriated for snow removal work, 275 miles of snow fence were placed, and an increased supply of equipment was purchased. The counties are also attempting to keep all the main highways open to traffic. In the northern part of Wisconsin considerable logging is done during the winter and it is necessary to leave about 5 or 6 ins. of snow for sleighing. This makes snow removal in the northern counties a little more difficult, but they are giving good service to both the sleigh and automobile traffic.

Highway Safety.—One of the growing evils on the highways is the number of automobile accidents which are responsible for upwards of 20,000 fatalities annually on the highways of the United States. Several items contributed to this alarming death rate but most of them show that the driver is responsible. There are a number of cases, however, where the condition of the highway has caused many very serious accidents. It is the duty of every highway worker to do everything possible to eliminate the causes for these accidents insofar as this work is concerned. The proper signing of a highway system does much toward informing the public of the dangerous and hazardous places along the highway. The marking of a centerline on paved roads also tends to reduce accidents. Much remains to be done in the separation of grades with railroads and also on high speed highway intersections. The dust problem on gravel and dirt roads is a very serious one. The states are beginning to cope with this, but when one considers that 80 per cent of the total rural highway mileage is unsurfaced, it can be readily seen that considerable thought and energy must be directed toward this problem.

Supervision and Coordination of the Work.—No activity can be carried to a successful conclusion unless it is properly supervised, and the forces involved properly coordinated. We find that it is impossible to get the best of service from the highway patrolmen unless they are properly supervised

and given attention from time to time by a superintendent or foreman. They try to do their best, but when any man is put out on the highway 10 hours each day with the small amount of supervision that he ordinarily gets, it is next to impossible to expect efficient results. Thus, by having one who can visit with the patrolman, exchange ideas from time to time, the results will be better maintenance at no increased cost.

County and State Road Schools.—To coordinate the work among the various agencies in the county and state, county road schools are held each year at the county seats, usually at the beginning of the season, in which all subjects pertaining to the maintenance of the highway are discussed. At these meetings the patrolmen are given a chance to speak freely and outline their ideas as learned from experience and to discuss with other patrolmen the advantages of carrying on their work according to the best methods. At this time when all the patrolmen are assembled, general instructions are issued to them by the Commission's representative. Any doubtful points are discussed and agreed upon. The county road schools are primarily for the benefit of the patrolmen, but they also serve as a coordinating influence between all those interested in the development of highways.

In order to discuss highway problems from a state wide view-point, an annual state road school is held at the state capitol. The law requires that every county committee and highway commissioner must attend these meetings. All citizens interested in highway work are invited and in many cases do attend all sessions of the road school. It is believed that the county road school and the annual state road school have been an incalculable influence in the development of the highway system in Wisconsin and have served to coordinate the work of all the counties to the extent that uniform maintenance has resulted throughout the entire state.

Service to All.—The above remarks have been directed primarily to state highway systems, but we are frank to say that no state highway system can be successful unless the secondary or local highways experience a parallel growth commensurate with their importance as arteries of transportation. In other words, to give the best service to all of the motoring public from the most remote farmer to the city dweller, it is essential that we have improvements made on the local and county roads as well as on the state highways.

Probably one thing that speaks more for the system employed in Wisconsin than does any other is the fact that county trunk systems patterned after the state system have been developed by all counties, and, in a great many instances, the influence has extended down to the town roads. The county trunk systems today total approximately 12,300 miles of secondary highways which are systematically maintained, marked and signed in the same manner as the state highways. Many of the towns have developed town systems and have placed patrolmen on the highways to keep them maintained at all times. It is believed that the results obtained on the state highway system through the plan adopted have been largely responsible for the development of the county trunk system and the improvement of town roads.

In conclusion may it be stated that it has not been the intention of this paper to cover the many details of the maintenance work which necessarily must vary with each state and locality. On the contrary, the purpose has been to point out a few of the important factors which when properly applied will make for better highway service. It is true that in order to carry these out it requires the expenditure of money, thought, and energy, but after all the amounts expended for maintenance are almost insignificant when we compare it with what the total investment is in highways and highway transportation facilities.

If we assume that each of the 800,000 motor vehicles owned and operated by the citizens of the state of Indiana travel 5,000 miles per year and that through efficient maintenance of the highways each owner is saved one cent a mile in operation of his vehicle, there would be a total saving of 800,000 x 5000 x 1 ct = $40,000,000. This looks like a large sum but I believe it is conservative.

States Built 20,000 Miles of Surfaced Roads Last Year

More than 13,600 miles of earth roads included in the State highway systems of the 48 States were surfaced by the several highway departments in 1926, according to information compiled from State reports by the Bureau of Public Roads of the United States Department of Agriculture.

The total length of surfaced roads constructed by State agencies during the year was 19,492 miles, of which 13,664 miles was laid over former earth roads and 5,828 miles represented a rebuilding of old surfaces.

The reports show that the total mileage of surfaced roads in the State highway systems increased by 18,205 miles during the year; but of this increase 4,541 miles represents no actual work by the States, but consists merely of mileage transferred from county to State jurisdiction, statistical changes resulting from resurveys, etc.

The above figures refer to increases in surfaced mileage on the State highway systems only and do not include surfacing laid by the counties or other local governments. They do include, however, all work done with Federal aid.

The statistical table issued by the Federal bureau shows that the combined State systems embrace 287,928 miles and that of this mileage 163,059 miles is surfaced and 28,456 miles is graded and drained according to engineering standards. The State systems are now about 66 per cent initially improved. The types of surfaced roads existing at the end of 1926 were as follows:

	Miles
Sand-clay and topsoil	11,396
Gravel, chert and shale	79,286
Waterbound macadam	18,428
Bituminous macadam	12,927
Sheet asphalt	890
Bituminous concrete	4,815
Cement concrete	31,935
Brick	3,215
Asphalt, wood and stone block	165

The mileage of road in the State systems and the mileage surfaced are as follows:

	Total mileage in state systems	Existing surfaced mileage at end of 1926	Mileage of new surfacing placed during year including reconstr.
Alabama	3,936.3	2,172.5	467.2
Arizona	2,031.4	1,421.5	75.0
Arkansas	8,346.0	4,153.0	358.0
California	6,582.1	3,537.9	265.4
Colorado	8,966.6	3,499.3	295.3
Connecticut	1,952.1	1,819.3	200.0
Delaware	590.5	590.5	84.8
Florida	5,654.0	2,725.3	349.5
Georgia	6,258.8	2,664.5	327.6
Idaho	4,668.4	2,437.6	269.4
Illinois	9,459.6	4,495.5	361.8
Indiana	4,262.6	4,155.3	376.7
Iowa	6,653.7	3,469.6	498.7
Kansas	7,887.0	1,338.5	403.5
Kentucky	9,646.6	4,192.1	197.6
Louisiana	8,000.0	4,707.2	594.5
Maine	1,574.8	1,306.1	135.1
Maryland	2,419.8	2,419.8	148.1
Massachusetts	1,563.7	1,550.9	102.8
Michigan	6,756.8	6,229.3	354.1
Minnesota	6,930.9	6,353.5	1,412.0
Mississippi	6,721.0	3,839.0	458.6
Missouri	7,640.0	3,375.8	822.7
Montana	7,957.2	926.9	119.2
Nebraska	6,256.0	2,764.1	833.8
Nevada	2,996.0	1,022.6	189.7
New Hampshire	2,256.6	1,963.4	169.4
New Jersey	1,457.8	1,296.9	50.5
New Mexico	9,214.4	1,684.8	73.9
New York	14,068.0	9,853.8	565.6
North Carolina	6,218.0	5,464.0	696.2
North Dakota	6,837.8	1,335.4	539.4
Ohio	11,000.0	9,591.0	2,411.2
Oklahoma	5,589.0	1,584.5	236.1
Oregon	4,468.6	3,220.4	293.6
Pennsylvania	12,033.4	8,439.6	751.3
Rhode Island	821.7	451.5	49.9
South Carolina	5,143.3	3,869.9	584.1
South Dakota	5,923.5	2,467.8	444.8
Tennessee	5,051.0	3,555.5	291.7
Texas	18,728.0	9,256.3	497.1
Utah	3,248.7	1,189.8	150.0
Vermont	4,462.0	3,139.0	139.0
Virginia	5,210.5	3,839.0	165.8
Washington	3,283.6	2,607.3	96.2
West Virginia	3,784.6	1,732.3	494.0
Wisconsin	10,279.6	8,420.4	962.0
Wyoming	3,136.2	929.1	129.4
Total	287,928.2	163,059.3	19,492.3

Slag-Clay and Sand Asphalt in Delaware

Two new types of paving were tried in Delaware during 1926—sand asphalt and slag-clay road. About six miles of the former was constructed to take advantage of local sand. This type is cheaper than concrete, and can take traffic within one day of laying. Slag-clay was used on secondary roads, a total of 19.4 miles being completed.

Super Highway Plan of Detroit Metropolitan Area

The Need for a Master Plan for Major Thoroughfares Discussed in Paper Presented at 13th Annual Conference on Highway Engineering at University of Michigan

By COL. SIDNEY D. WALDON

I would like to impress upon each of you the urgent necessity of creating plans now for the gradual reshaping of the old horse and buggy standards of street and highway width in your respective districts, in order to more promptly meet the new requirements of the automobile and, in densely populated cities, those of train operated rapid transit as well. Some of you may have already sensed the need, and be actively engaged in this work. My remarks will be mainly addressed to those who have not seen the picture of our changing requirements as clearly as we do here in Detroit.

Briefly I want to show you that the population of this country is increasing at a rapid rate; that automobile ownership is increasing at a more rapid rate than population; that automobile use is going ahead faster than we can provide new facilities to meet the increases in automobile ownership and traffic. I want to show you that the adoption of proper standards and their application to a master plan of major thoroughfares and superhighways, backed up by competent legal and executive authority will make the passage of time an ally of immense power, whereas without a master plan the passage of time becomes an implacable enemy working to defeat our efforts to obtain relief.

Population Tendency.—Let us look at the population tendency of the United States as a whole. The census of 1790 gave a total for this country of 3,930,000. Eighty years later the population had increased to 38½ millions or to almost ten times in eight decades. In 1920 the population was 105,700,000. During those five decades from 1870 to 1920 the lowest increase per decade was 11½ millions and the highest approximately 16 millions.

A press clipping in the January 16th, Sunday Detroit News quotes W. M. Steuart, director of census, and Dr. Joseph A. Hill, chief assistant, as estimating an increase of 18 millions for the present decade 1920 to 1930. Let us be conservative and assume that we will not continue to grow in population at an increasing rate and let us assume that we will not even grow at the figure estimated for the present period but only at an average of 15 millions per decade for the next 70 years. Seven decades at 15 millions per decade is another 105 millions or the equivalent of the entire population of this country as of 1920. It is reasonable to assume that during the span of life of many children born today there will be created a second United States so far as population is concerned, which must be superimposed upon the one in which we now live. Every successive increase in population will bring into being its additional traffic burdens and problems to be added to those that already exist.

What are we doing to plan for the larger requirements of this vastly greater population that is immediately ahead of us?

So much for the tendency of population.

Automobiles—The Medium for Individual Transportation.—Within the past 25 years there has been created a new medium for individual transportation that is working one of the greatest revolutions in man's mode of living that has occurred since the beginning of time. Prior to the coming of the automobile the individual was dependent upon his own efforts, walking or running, or upon the ox or the horse for individual transportation. For eighteen centuries he moved within the limited radius prescribed by these restrictions. Individuals of town and farming communities were isolated from each other for months out of each year by impassable roads.

And now this restriction to individual travel has been banished forever. The farmer's isolation has become a thing of the past. All that the city holds in the way of a market for his produce or for the health, education and recreation of his family is readily accessible to him all the year around. The factory worker, who formerly had to live within sound of the factory whistle, can visit the country at will or live out in the open sunlit places. Given good roads, and the motor car is railroad train and trolley car combined, without their limitations as to fixed routes, stations or time tables. The automobile is rapid transit on rubber tires for the individual.

Increase in Automobile Ownership.—Twenty-five years ago there were less than 15,000 motor vehicles in the United States. Today there are well over 22,000,000. During 1926 the industry produced approximately 4,500,000 motor vehicles or almost 1,000,000 more than were registered in the entire country ten years ago.

In 1920 we had in this country a motor vehicle to each eleven persons. Now we have one to each five persons. In California the ratio is one automobile to each three persons and the tendency of the rest of the states is toward the same or a lower ratio.

The greatest increase in registration occurs in those states already having the largest number. The six states of New York, California, Ohio, Pennsylvania, Illinois and Michigan, added last year 866,000 motor vehicles to the 8,000,000 they previously had, or over 10½ per cent.

So much for automobile ownership which is increasing more rapidly than population and seems to be headed towards a ratio at least as low as one motor vehicle to each three persons.

Increase in Use.—In thirteen years Detroit's population has doubled while motor vehicle registrations have increased over ten times. In the same period of traffic counts on Grand River Ave., one of our main trunk line highways, shows an increase of 34 times.

A year ago Wayne County built 55 miles of new concrete roads but in the same twelve months' period registrations in the county increased over 53,000 or almost one thousand vehicles to each mile of new surface. Automobile use is increasing faster than the facilities to take care of it.

Hard surfaces are no longer the only consideration. We must provide wider streets and highways not only to meet the needs of the moment but in order to prepare for the much greater requirements of the future. Improved facilities for transportation invite traffic and benefit most the sections providing the improved conditions.

What of the Future?—If 210 millions of population is possible in this country in another seven decades, and if we are headed toward a ratio at least as low as one motor vehicle to each three persons, then there will be in the neighborhood of seventy millions of motor units trying to find space for travel upon the streets and highways of this country within the scriptural span of three score and ten years, where we are already congested with only 22 millions today.

Remember that we are increasing population, according to the Census Bureau, at a greater rate than 15 millions per decade. But whether we reach these figures in seventy or eighty years is not the important point as much as the fact that we are irresistibly moving toward that objective. What lies beyond we will not now conjecture. It is enough that our civilization will never relinquish the automobile, and both population and automobile ownership and use are bound to grow.

What of Finance?—Twenty-two millions of automobiles last year paid in taxes of all kinds to the city, state and federal governments almost three-quarters of a billion dollars. Seventy mil-

lions of motor vehicles at the same rate would make an annual contribution of 2 1/3 billions of dollars, or more than enough to finance six Panama Canals every year.

Last year Michigan's motor vehicles paid over 27 millions to our state government, or an average of a little less than $25 each. In just about 30 years the normal growth in population and registration will have increased this total to 50 millions annually (or the equal of our recent highway bond issue) to be spent every twelve months by state and county. Within the same seventy-year period Michigan's population will be in the neighborhood of 9 millions, five of which will be in the Detroit area. Michigan's total registrations will be at least three millions. With annual taxes at the same rate there would be 75 millions per year available for road building purposes.

It is perfectly apparent that such increases in population, registration and revenue all lead to the necessity for the most earnest consideration of the very foundation of our highway system, namely, the width of right-of-way, that is, the distance from property line on one side to the property line on the other.

Right-of-Way.—Right-of-way is like the land a manufacturer buys upon which to build his factory. Ninety-nine out of a hundred business men would refuse to make a permanent investment in plant upon a piece of ground only just big enough for immediate needs. Common sense would dictate the acquisition of enough extra land at the original low cost before the building of the plant itself made the adjoining land too valuable to buy for further expansion.

We must lay aside our ox cart and horse and buggy yardsticks of right-of-way width and adopt new ones that fit the motor vehicle. What was an adequate width of street or highway when this country had 38 millions of people and the stage coach was regarded as a flying machine, is obsolete with 100 millions of population that can all be put on rubber tires at one time. These same standards will be hopelessly impossible when we have doubled our present registrations and practically useless when total registrations are trebled.

To make our present plans based solely upon our existing situation without any provision for the future is the extreme of shortsightedness.

Effect of Time.—With population and automobile ownership and use increasing rapidly, changes are continually occurring in the shape of improvements along every main traveled route. Without careful planning, conditions grow steadily from bad to worse. Dead ends, sharp turns, dangerous corners, bad alignments that could easily be remedied in the open country, become tremendously expensive when hemmed in by tall buildings as part of town or city. Ninety-nine per cent of our present traffic troubles exist because in the past no one foresaw the coming of the automobile and few gave a thought to the future, which to us is the present.

A reasonable and forward looking plan once proposed and publicly accepted never dies but continues to attract and inspire its own champions. Time works in its favor and makes accomplishment possible at minimum cost, over a period of years, that would be impossible otherwise. Forethought costs nothing but may be made to save millions in future expense. Wise planning makes time a powerful ally.

Width of Right-of-Way.—The public does not generally understand the difference between width of right-of-way and the width of pavement. They confuse roadway with right-of-way.

A narrow pavement in a wide right-of-way can be increased at any time, but a narrow pavement in a narrow right-of-way, particularly through a thickly built up and congested district is well nigh hopeless.

The foundation of the whole structure of any plan for present and future transportation lies in the standards adopted for the various widths of right-of-way and the subsequent adherence to those standards.

Master Plan.—What is needed in every village, town and city in every township, county and state is a master plan of the main arteries of transportation.

Today no community can afford to consider its situation as separate and distinct from the communities with which it is linked by trunk line highways. The automobile and good roads flood the streets of the remote hamlet with the traffic of a great city.

In our opinion every village in this country should adopt a standard of not less than 120 ft. of right-of-way for the two thoroughfares that intersect at its business center, and should steadfastly work to acquire that width up on its two main streets and upon the section line roads that come within its influence.

120-Ft. Standard.—In thinly settled states or sections where land is cheap, the right-of-way can be made 120 feet just as well as any other width. In the snow belt the wide right-of-way may be the cheapest investment for dropping the drifts far enough from the traveled road surfaces so as to minimize the cost of snow removal. In thickly settled states the traffic will demand wide rights-of-way along all the important main arteries.

The village requires 120 ft. because of the space using automobiles and the need of parking space for its own business without blocking the through travel. The great city requires 120 ft. because it must carry the great bulk of its mass transportation below ground. No opportunity should be lost by the village to acquire the 120-ft. widths as early as possible.

Detroit, the counties of Wayne, Oakland and Macomb, and the contained municipalities, have created and adopted a Master Plan of superhighways and interior thoroughfares.

Superhighways are 204 ft. wide.

Mile section line roads and interior throughfares are 120 ft. wide.

Quarter section roads and secondary streets are 86 ft. wide.

Residence streets are 60 ft. wide.

Automatic Dedication of Right-of-Way.—Adoption by the three counties means that no plats for subdivisions are accepted by the several boards of auditors, that do not provide for dedications of rights-of-way to the standards prescribed along the particular routes affected.

Like the mill of the gods this one provision is automatically and continually grinding out the necessary widths of rights-of-way all over the metropolitan area as our population and traffic grows. Time is working for us and not against us. It is not only saving untold millions of dollars in future condemnation suits, but through establishing a greater potential traffic capacity it is stimulating a more valuable development of the property served and is thereby increasing taxable assets.

Super Highway Commissions.—In addition to this method of the three county boards of auditors, private property owners associations are doing wonderful work along the master plan routes in which they are especially interested. Added to these influences are county and state highway commissions, and a new form of organization created under special act obtained for that purpose, known as superhighway commissions. The latter are created solely for the purpose of acquiring rights-of-way, the improvement of which rests with the road commissions as before.

What has been said about the superhighway portion of the master plan applies particularly to large cities and their suburbs. In principle it is applicable to every village, town, city, county and state in the country. Potentially great cities with heavy motor vehicle registrations demand a network of 204-ft. superhighway rights-of-way, while trunk line routes of major importance across the states should not be less than 120 ft. wide from fence to fence.

Right-of-Way Acreages.—A mile of 66-ft. right-of-way contains 8 acres of land while a mile of 120-ft. right-of-way contains 14½ acres. The difference is 6½ acres per mile. Along one of our trunk line roads the average cost of land purchased at its assessed value for widening the right-of-way was $400 to $500 per mile, and fence replacing cost $700 per mile. The two amounts, together, only approximated 3 per cent of the average pavement cost. There was some additional expense for removing buildings.

Penny Wise, Pound Foolish Policy.—In our opinion it is economically unsound to invest $35- to $40,000 or more,

per mile in hard surfaced roads in a right-of-way of 66 ft. when at so little increased cost it can be brought up to what should become the trunk line road minimum for the entire United States. It should not be less than 120 ft. The pavement invites traffic and enhances the value of the land adjacent and served. Traffic creates business and encourages the erection of buildings which hug the narrow right-of-way. To widen requires the destruction of buildings and the payment of high land prices created by reason of the service given by the pavement. An adequate width of right-of-way should be considered as of just as much importance as the thickness of the concrete or the preparation of the subgrade to receive it.

Right-of-Way Law.—If the wisest thing was done for this country, Congress would pass a law under which no federal aid money would hereafter be spent on any national trunk line highway, the right-of-way of which was below a minimum standard width of 120 ft. Failing this the several states should enact such legislation. The very least that should be done would be for the various states to pass setback laws prohibiting the erection of buildings within 60 ft. of the center line of any concrete or hard surface pavement upon the federal and state trunk line highway systems.

The foundation of the whole structure is the width of right-of-way. The very first operation, therefore, and one that should precede or be coincident with the laying of the first improved road surface should be the acquisition (or reservation by setback lines) of the necessary land to provide for successive widenings of the pavement in keeping with the strategic importance of the route. While laying the pavements to serve the 22 millions of motor vehicles today we must keep in mind the vastly greater needs of the 30, 40, 50 and 70 millions of tomorrow.

Acquiring these rights-of-way will not happen of itself. It must be brought about through the preparation of a logical plan that will not only set up the necessary legislative foundation, but will effectively unite the active interest and support of all the officials best able to carry the plan through to a successful conclusion.

This is no time to spend in vain regrets for what was not done in the past. Let us forget the mistakes and omissions of yesterday. Our forefathers could not foresee the coming of the automobile. But let us keep constantly before us the fact that during the next 70 or 80 years we are going to add another 105 millions to the population of 1920, and another 50 millions to our motor vehicle registrations. Let us remember that only through the adherence to a master plan can our growth be orderly and in proper relation to our growing needs. Let us sink our superhighways as deeply as possible into the outskirts of our great cities, and then work outwards. Let us make 120 ft. the minimum standard right-of-way width for every federal and state trunk line highway in this country.

Let us remember that traffic, and with it development, goes where it is invited and stays where it is well treated. Let us remember that those sections will benefit most that contribute most to the success of the plan. Also let us remember that we can do today simply, as the result of the existence of a logical plan what may cost millions, or be impossible, tomorrow.

The untouched opportunities of the present are almost without limit if we have the vision to see and the will to do.

Highway Research Activities in Minnesota

An interesting summary of the research work now being carried on by the Minnesota State Highway Department is given by F. C. Lang, Engineer of Tests and Inspections, Minnesota Highway Department, in the March Highway Research News, from which we quote as follows:

At the present time the laboratory is carrying on the following investigations in co-operation with other agencies:

1. Effect of tensile strength of cement on the strength of concrete.
2. Standardization of field transverse concrete beam testing machine and method for use.
3. A new method of testing sands using water cement ratio.
4. Use of calcium chloride integrally as an admixture and curing agent.
5. Study of fluid cement water mixtures as a criterion of the concrete making value of Portland cement.

Independently of other agencies we are conducting the following investigations:

1. **Effect of shape and character of aggregate on resulting strength of concrete.** — Compressive and transverse tests are being made, using, under identically the same conditions, a smooth, uncrushed, impervious igneous gravel as coarse aggregate, a crushed limestone, a crushed trap, a commercial gravel containing cracked oversize, and a porous sandstone. The specimens are all broken at 3, 7, and 28 days. Results will be available about April 1, 1927. In these tests the absorption of aggregate is being allowed for in computing water cement ratio.

2. **Frost protection necessary for concrete.**—This investigation was started at the Duluth laboratory last year and is being continued at the same place. Concrete beams are exposed to freezing at different ages and some are repeatedly frozen and thawed. Beams are also cured indoors at two temperatures above freezing point, approximately 40° F. and 70° F.

3. **Durability of paints.** — Approximately two hundred panels have been placed in this exposure test beginning in the spring of 1926. Some results are now conclusive.

4. **Bituminous treatment of gravel roads and earth grades before graveling.**—This we consider the most important and far-reaching investigation that we are carrying on. In this State there is a trunk highway system of approximately 7,000 miles, of which there are about 850 miles paved and over 5,200 miles of gravel. In some localities, gravel is scarce and expensive and its conservation is very important. Some of the gravel roads should and will probably soon be paved as they are carrying very heavy traffic. There still remains a large mileage where the traffic is not heavy enough to justify paving and yet the gravel surfacing is unsatisfactory, both on account of the cost of the gravel and the dust nuisance to motorists and residents along the highway, as well as the inability to maintain a smooth riding surface at all times. The gravel as used in this State contains from 40 to 75 per cent passing a No. 10 sieve, so in many instances there is not much actual metal in the surface. In addition, there is a considerable variation in the quality. It is placed on all kinds of subgrades from heavy clay to granular soils. We are attempting to determine the best materials to use for various conditions of gravel and subgrade. In 1926 we constructed 81 miles of tar on gravel, 66.5 miles of oil on gravel, and 61.5 miles of oil on earth subgrade just previous to graveling. Several different kinds of road oil were used. Careful records of application procedure and maintenance costs are being kept. Bituminous materials and soils are analyzed. This investigation will be continued, with special observation during the spring break-up on heavy soils. The investigation was started in 1924.

Vibrolithic Pavement.—In October, 1921, about 2,200 feet of Vibrolithic pavement was constructed, using different proportions and different kinds of aggregate. In this 2,200 ft. ten different sections were laid. The effect of lean mixtures is now apparent. There has been no maintenance up to the present time except filling cracks.

Concrete Pavements.—Concrete pavements have been under observation for several years. As a result of study and observation we are now constructing contraction joints every 40 ft. 4 in., making the opening clear through the slab and filling the surface where a cap has been removed with bituminous material. Pavements similarly constructed about three years ago with longitudinal joints are practically free from cracks.

Indiana Road School Well Attended.—Over four hundred engineers and officials interested in Indiana's paving work attended the thirteenth annual Purdue road school in La Fayette, Indiana, this year.

Stone Bases for Roads

Suggestions on Their Construction to Meet Modern Traffic Conditions Given in Paper Presented June 13 Before Louisiana Engineering Society

By RODMAN WILEY

Vice-President and Sales Manager, Kentucky Rock Asphalt Co.; Formerly State Highway Engineer of Kentucky

As you are aware, traffic conditions have changed greatly in the last few years, yet today we are building macadam roads and stone bases the same way they were built 15 years ago. As a general proposition, the type does not prove satisfactory and, in my opinion, it is not the fault of the stone base, but the fault of the engineers designing and building it.

Recently, some real thought has been given to the design of broken stone bases; this, with particular reference to lateral displacement and subgrade conditions. It is my opinion that the principal failures of macadam and other types of stone bases are due to the fact that the voids have not been properly filled. This results in internal wear, causing an uneven surface.

In all the discussion that follows I am taking it for granted that drainage and unusual subgrade conditions will receive proper attention.

Base Laid in Thin Courses.—I suggest that a broken stone base be laid in thin courses so that the voids can be filled. The first course should be laid not over 4 in. loose, the stone shaped to the proper cross-section of the road and lightly rolled. I do not believe the roller should pass over it more than twice before screenings (¾ in. to dust) are applied and broomed in. All visible voids should be filled, then roll once or twice. Again apply screenings, broom and roll. Repeat this operation until the voids remain filled after thorough rolling. By lightly rolling and spreading the stone in such a thin layer the screenings, under the action of a roller, will shake down through the course of stone and thoroughly fill all voids; but if a thicker layer is spread, or if the stone is keyed too much before screenings are applied, the result will be that the course of stone is only checked for a depth of 1 or 2 in. below the surface, leaving the stone in the lower part of the course free to move.

This course should be lightly watered, but in no event with enough water to saturate the subgrade.

It is important that the stone and screenings be dry, otherwise it will be impossible for the screenings to sift down and fill the voids.

The second and third courses should be built as outlined for the first, except that the last course should be waterbound. The road should then be closed to traffic three or four days to allow it to dry. Excess screenings should be broomed off and the top laid.

It has been my experience that if the stone is spread in thin courses and care used in rolling, it is an easy matter to completely fill the voids and this will result in a rigid base, one that will remain smooth for all time.

This msthod of construction is no more expensive to the contractor than the method now used, except more screenings are required.

The average portable crusher will not, as a general proposition, make sufficient screenings, but this can be met by putting in a machine that will make screenings or else ship in desired quantity.

The thickness of such a base to carry modern day traffic must be left to the judgment of the experienced engineer.

A great many of us who have actually built roads in the capacity of contractors believe that greater stability is obtained when the first two courses are laid in one season and traffic allowed to pass over the base during the winter. The weak places that develop can be corrected in the spring and the top course laid.

Modified Telford Base.—The modified telford base came into some favor a few years ago. This was perhaps because of the wonderful service received from telford bases built throughout the country, especially in Kentucky, between the years of 1810 and 1838. There are today in existence in Kentucky many sections of telford base laid 80 to 100 years ago. Such sections have been unprotected by a proper wearing course of stone or by any water-proofing material, yet they have withstood the action of traffic—have supported the loads. It is true, the work was done with a great deal of care and this was possible because of the cheapness of labor in those days. It does prove that design and details of construction really count—results in a worth while structure.

We know that some men will use the same amount of stone as that used by others under identical conditions, yet some roads are better than others. This shows the importance of details of construction.

There has been some dissatisfaction with the modified telford base in the last few years because of the fact that the surface would in a few years become uneven. Again I must say that I do not believe it is the fault of the type, but rather that it is due to faulty design and construction. The stone should, of course, be set shingle fashion, the idea being to break joint, the greatest dimension side of the stone set on the ground. The course should be about 8 in. in thickness and especial care should be taken to get the stone as near to ideal shape as possible. But the principal idea is to have each stone 8 in. in depth after knocking off the tops. Do not have some stone 8 in. deep—some 5 in., etc., and attempt to bring to proper thickness with spalls in an effort to use all stone shot down in the quarry. The fine pieces which are easily knocked off with a hammer will serve to chink and level up the course.

After knocking off the tops, the voids should be thoroughly filled with some very fine material. The idea in using a fine material is to be certain it will sift through for the full depth of the course and completely fill the voids. It is best construction to do most of the void filling before very much rolling. In order to insure even compression some fine stone should then be spread on top of the telford to properly even up the rough surface. Then roll until the course is well compacted. Apply more screenings, lightly water and roll.

Next apply a levelling course about 3 in. compacted. Fill the voids with screenings and water-bind. I think that if a base of this type is properly constructed it is one of the best types to build.

If greater depth is needed, add another course of stone and water-bind.

There are many sections of the country where sandstone and other soft stone can be found in abundance and I am sure that it can be used economically for a base under some kind of an asphalt top.

I have merely discussed the waterbound macadam and the modified telford base. It is believed that these types cover the general field. All others will be modifications, made necessary to suit some local conditions. The main thing, regardless of type or size of the stone, is to fill all the voids.

We should study soil conditions and design each section of the road according to supporting power of the soil and loads that must be carried, just the same as we study these things when designing a bridge abutment or pier. It is rank foolishness to arbitrarily build the base the same thickness and type for the entire length of the road.

Reconstruction.—There are now over our country a great many old roads surfaced with macadam and gravel where the alignment, drainage, etc., is good and about all that is needed is to strengthen the base and add a bituminous top.

It is little short of criminal not to conserve the present investment in the surfacing. Good engineering naturally implies conservation, not destruction.

I think the best construction is to dig a trench across the road the width of a shovel at many places and measure the depth of the present base. For the purpose of calculating the amount of new material to use—consider the present base 50 per cent of its real depth. In other words, if the base measures 6 in., value it at 3 in. The reason for this is the fact that the old metal is filled with dirt and other foreign materials and certainly should not

be given a much greater value as compared to new stone and new gravel.

It has been my experience that the best way to proceed with such construction is to fill the hones, ruts, etc., in the present surface with stone or gravel —lightly scarify the surface and properly shape it with a grader.

There may be some question as to scarifying, but it is believed best to do this, especially if less than 4 in. compacted new material is to be added.

By filling the holes before scarifying, the weak places will be properly strengthened. If the holes are not filled before scarifying, it is my experience that the depressions will follow the base to the surface because very fine material will be dragged into the low places when the road is shaped with a grader and there is no stability to the fine material dragged into the holes.

After the surface is properly shaped, new material can be added for a sufficient depth to make a stable base.

Industrial Notes

Lynn B. McKnight, who for the past eight years was associated with the Dodge Manufacturing Company of Mishawaka, Ind., in various sales capacities, has been appointed sales manager of the Stearns Conveyor Company of Cleveland, manufacturers of Stearns Belt Company and Silo Storage Systems. Mr. McKnight was with the Dodge Manufacturing Corp. from 1919 to 1921 at their home office in Mishawaka, Ind., and in 1921 was sent to the San Francisco office to take charge of the Pacific Coast for Dodge. In 1923 he was made sales manager of the Cleveland and Pittsburgh district. Mr. McKnight is a graduate of the School of Mechanical Engineering of Purdue University, Lafayette, Ind., 1915.

The Stearns Conveyor Co., manufacturers of belt conveyors, is owned by Chain Belt Company of Milwaukee.

The Waukesha Motor Company, manufacturers of heavy duty Ricardo Head industrial and vehicle engines, have opened their new eastern sales office at 8 West 40th Street, New York City. This office was formerly in the Aeolian Building, 33 W. 42nd Street.

The Industrial Works, Bay City, Mich., manufacturers of shovels, cranes and draglines, equipped with crawler or rail mountings, announces the closing of their district office formerly located at 823 South Oregon Avenue, Tampa, Fla., effective immediately. The district office at Atlanta, Ga., located in the Hurt Building, that city, will handle all of Florida, Alabama, Georgia, North Carolina, South Carolina and the eastern portion of Tennessee.

Harnischfeger Corporation, factory and home office at Milwaukee, Wis., recently exported eleven of their latest model excavators to Cuba. These eleven machines are now working on the longest paved highway ever covered by a single contract. The Central Cuban Highway will extend almost the full length of the island, passing through the provinces of Pinar Del Rio, Havana, Matanzas, Santa Clara, Camaguey and Santiago. This long highway will be paved with Warrenite Bitulithic, a product manufactured by Warren Brothers Company, the principal contractors on the job. P&H machines are being used exclusively, and many dragline, shovel, clamshell and skimmer scoop attachments were purchased by the contractors with which to meet every requirement in connection with highway construction work.

It is estimated that an expenditure of $75,840,000 is involved in financing this extensive project. The finished paved highway will be more than 700 miles long. Carlos Miguel De Cespedes, Secretary of Public Works, has pledged its completion in 1931. In addition to the eleven P&H excavators employed on the Central Cuban Highway, the Cuban Government has purchased four machines with which to carry on a program of municipal and port improvements.

Splitdorf Electrical Co. have recently appointed the following service stations: H. A. Kennedy, Larned, Kan.; Blount's Electric Service, Market Street at Sixth, Washington, N. C.; Roy C. Bradley, 371 East 4th Street, San Bernardino, Cal.; Fullerton Auto Electric Co., 140 West Commonwealth Avenue, Fullerton, Cal.; Cheatum Electric Co., Liberal, Kan.

The Willamette Equipment Company of Portland, Ore., are now authorized representatives of the Galion Iron Works and Mfg. Company, for the state of Oregon.

They will handle the complete Galion line of road graders, road rollers, motor graders and other road building and maintenance equipment.

The sale of the New Galion Leaning Wheel E-Z Lift graders and Galion McCormick-Deering E-Z Lift motor graders will receive special attention and with other machines will be stocked at Portland.

A good supply of Galion tough, hard alloy steel grader blades will also be carried in stock by them to fit practically all makes and sizes of graders in use in Oregon.

This progressive concern is very well known in their territory and are looking forward to a large business in Galion Road Machinery.

Harnischfeger Sales Corporation of Milwaukee announces that due to increased volume of business it has become necessary to make the following additions in the sales department of their organization: Mr. R. S. Breyman, Mr. M. A. Germond, Mr. D. Graze, Mr. Deane S. Holt and Mr. J. C. Yetter.

W. H. Williams has been added to the Splitdorf Electrical Co. field service division. Mr. Williams is at present traveling Pennsylvania and adjacent states calling on Splitdorf service stations, branches, highway departments, agents and distributors of manufacturers using Splitdorf automotive equipment. Announcement of the appointment was made by L. E. Farine, manager of the Splitdorf products service.

Mr. R. P. Shimman, of the Link Belt Company, has been appointed assistant to the chairman and the president, and will, hereafter, make his headquarters at 910 S. Michigan Ave., Chicago, the general offices of the company.

Mr. Frank B. Caldwell has been appointed sales manager of the same concern, with headquarters at the Chicago plant office, 300 W. Pershing Road, and will have supervision over all sales activities in the Western Division.

William Ogden, better known to his many friends as "Bill," who has been associated with the Lakewood Engineering Company for the last five years, has left that company to become the manager of the State Highways Division of The Austin-Western Road Machinery Co. of Chicago.

G. F. Schlesinger, Director of Highways and Public Works, State of Ohio, announces the appointment of Mr. Fred E. Swineford of Akron, Ohio, as chief engineer of the Bureau of Maintenance of the Division of Highways effective July 1, 1927, succeeding Mr. George E. Carr, resigned. Mr. Carr has not definitely decided his future employment although he is considering several attractive offers.

Mr. Swineford has been division engineer of Division No. 4 with headquarters at Ravenna, Ohio, since July, 1923. Prior to that time he was employed in the department as assistant resident engineer. He is a graduate of Ohio State University with a degree of civil engineer in 1915.

Mr. Swineford will be succeeded as division engineer in Division No. 4 by Mr. L. A. Breen who at the present time is assistant division engineer at Ravenna. Mr. Breen has been connected wth the Highway Department since March, 1916. He received his college education at the University of Akron.

These appointments are in line with the fixed policy of the department to promote employees in service whenever justified by their record in the department.

C. W. Hall, formerly manager of the Lansing distributing branch of the Olds Motor Works and later with the Reo Motor Car Company, has joined the sales department of the Duplex Truck Company of Lansing, Michigan.

The Selden Truck Corp., Rochester, N. Y., manufacturers of Selden Motor Trucks, have announced the following new dealers:

Southern California
H. G. Pendell, Inc., 1253 So. Hoover St., Los Angeles.

Philadelphia and Vicinity
G. G. White, 1523 Brandywine Ave., Philadelphia.

Hagerstown, Md., and Vicinity
Wood's Auto Service Co., 805 Pennsylvania Ave., Hagerstown.

Newburgh, N. Y., and Vicinity
Harcourt Motor Co., 245 Broadway, Newburgh, N. Y.

Ohio
Thomas Hillman, Mansfield, Ohio.
W. E. Ellis, Findlay, Ohio.

The same concern has appointed W. L. Poffinberger, of Bellevue, Ohio, as district representative in Northern Ohio, while C. M. Thorpe, with headquarters at Standard Supply & Equipment Co., has been appointed district sales manager for Selden Trucks in Philadelphia and surrounding territory.

New Trade Publications

Dragline Buckets.—The Blaw-Knox Company, 601 Farmers Bank Building, Pittsburgh, Pa., in a folder recently issued, describes a new dragline bucket that they now manufacture. This is the bucket that was on display at the Road Show last spring. The bucket that was on display, according to the folder, was purchased by a prominent Chicago contractor, and has since then been working on a 30-B Bucyrus crane, equipped with a 45 ft. boom, digging an artificial lake for the new zoo at Riverside, Ill. This 1¼ yd. bucket, it is said, is giving a good account of itself. Other sizes, from ⅛ yd. to 2 yd. capacity, are now available.

Graders.—The Wehr Company, of Milwaukee, Wis., manufacturers of a one-man Fordson-powered grader, have just sent out an interesting leaflet, on one side of which is described the grader, while the reverse bears an interesting poem by W. H. Burns, County Commissioner of Gem County, Idaho, bewailing the fate of the county commissioner.

Steel Posts.—The Sweet's Steel Company of Williamsport, Penn., has just issued a new booklet describing their complete line of Herculean Special Flanged Leg Channel Section and Herculean Steel Posts. The booklet is profusely illustrated with steel post adaptations for fences of every description, sign posts for highway markers, road intersections, etc.

Power Shovels.—The Speeder Machinery Corporation, of Cedar Rapids, Iowa, manufacturers of the Speeder one-half yard convertible shovel, have issued a new 32-page catalog showing many cases in which this machine has been used as a power shovel, crane, dragline, skimmer, or trench pull-shovel, handling all types of digging. Not only are these installation pictures worth examination, but the catalog contains full data and specifications of the machine as well, and such information is assembled in a way that should prove helpful to the prospective purchaser.

Power Shovels.—The Thew Shovel Co., of Lorain, Ohio, describe, in a recently issued circular, their Lorain 75, equipped as shovel, crane, and dragline, telling by word and by photograph how the machine so equipped has been used by contractors on many jobs. Prominent among the work shown is a big dirt moving job in Texas where the dump wagons used on the job held but one dragline bucket full of dirt.

Graders.—The Austin Manufacturing Co., Chicago, Ill., have just issued an interesting circular describing their leaning wheel graders equipped with the telescopic axle feature. A new complete catalog has also been issued that shows the same equipment in greater detail.

New Books

Bridge Architecture; by Wilbur J. Watson, C.E., A.S.C.E.; William Helburn, Inc., 15 E. 55th St., New York City, Publishers; 11x14, 288 pages, 213 illustrations, 66 pages of explanation and history of structures, together with biographies, etc. Edition limited to 1500 copies, board covers. $17.50.

The purpose of this interesting book is to illustrate the art of good bridge design, both as to composition and detail, as exemplified by ancient and modern bridges, illustrating the principles by means of a wealth of carefully selected photographs. Over two hundred illustrations, most of which are full page plates, are classified according to period and for modern bridges, into types. The text includes descriptions of many of the bridges illustrated, some historical data, and considerable literary and legendary lore, all of which should prove interesting to the engineer and the architect. Technical terms have been avoided as much as possible. This book, illustrating as it does many good designs of past centuries and of today's engineers, has a definite inspirational value for the man who is as interested in the architectural design of his bridges as he is in the engineering design of the structure.